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MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

VOLUME XXV, 1986

COMPLETE IN TWO QUARTERLY ISSUES

CONSISTING OF v + 673 PAGES

INCLUDING FIGURES

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Published by

MYCOTAXON, LTD., P.O. BOX 264, ITHACA NY 14851, USA

Printed in the United States of America

TABLE OF CONTENTS, VOLUME TWENTY-FIVE

No. 1 January-March 1986

Notes on Entomophthorales (Zygomycotina) collected by T. Petch: **Erynia anglica** comb. nov. and **Erynia coleopterorum** ..... ISRAEL S. BEN-ZE'EV 1
A new entomogenous species of **Cordyceps: Cordyceps ithacensis** sp. nov. STANISŁAV BAŁAZY and ANNA BUJAKIEWICZ 11
On **Dinemasporium adeanum** Petrak. T. R. NAG RAJ and BRYCE KENDRICK 15
Taxonomic notes on **Diatrypella discoidea, Diatrypella decorata,** and **Diatrypella placenta** ..... DEAN A. GLAWE 19
The "**Pleurotus silvanus**" complex ..... R. G. THORN 27
Basidiomycetes that decay Gambel oak in southwestern Colorado: II. ..... J. PAGE LINDSEY 67
New species in the lichen family Parmeliaceae (Ascomycotina) ..... MASON E. HALE, JR. 85
Taxonomic concepts in the Endogonaceae: II. A fifth morphological wall type in endogonaceous spores. CHRISTOPHER WALKER 95
Marine Pythiaceae from decaying seaweeds in the Netherlands ..... A. W. A. M. DE COCK 101
A new sporocarpic species of **Acaulospora** (Endogonaceae). N. C. SCHENCK, JOYCE L. SPAIN and EWALD SIEVERDING 111
Some more observations on eastern Himalayan Helotiales. RAGHUNANDAN SHARMA, WOLF-RÜDIGER ARENDHOLZ and K. S. THIND 119
A corrected authors index for A Bibliographic Account of Exsiccatae Containing Fungi ..... DONALD H. PFISTER 141
The new species **Dekkera naardenensis,** teleomorph of **Brettanomyces naardenensis.** SHUNG-CHANG JONG and FWU-LING LEE 147
Tolypocladium, a synonym of **Beauveria** ..... J. A. VON ARX 153
Modification of Nobles' species code for identification of basidiomycete cultures ..... GEORGE P. CHAMURIS 159
Dermatiscum fallax (Physciaceae), a new lichen from southern Africa ..... FRANKLIN A. BRUSSE 161
On the anamorph of **Phillipsia crispata** ..... JOHN W. PADEN 165
Experiences in computerizing the National Fungus Collections' specimen label data ..... DAVID F. FARR 175
The ecological and geographical distribution of 108 species of macromycetes from the subtropical, evergreen, broad-leaved forests in China ..... HUI-CI TAN and REN-JIAN WU 183
Alternaria themes and variations (14-16) .. EMORY G. SIMMONS 195
Alternaria themes and variations (17-21) .. EMORY G. SIMMONS 203
Glomus maculosum sp. nov. (Endogonaceae): an endomycorrhizal fungus .. DIANE DOUD MILLER and CHRISTOPHER WALKER 217
Four new Japanese species of the Ceratostomataceae (Ascomycetes). YOSHIKAZU HORIE, SHUN-ICHI UDAGAWA and PAUL F. CANNON 229
Notes on hyphomycetes. LI. **Kameshwaromyces,** a new foliicolous, sooty mold-like genus from Madhya Pradesh, India. KAMAL, R. V. VERMA and GARETH MORGAN-JONES 247

Arctoparmelia, a new genus in the Parmeliaceae (Ascomycotina) ..... MASON E. HALE, JR. 251
Hormotheca for species of **Coleroa** with hemispherical ascomata ..... MICHAEL CORLETT and MARGARET E. BARR 255
Taxonomic notes on some powdery mildews of various genera. UWE BRAUN 259
Typification of **Dimeromyces isopterus** (Laboulbeniales). JAMES W. KIMBROUGH 271
Notes on Corticiaceae (Basidiomycetes) XIV ... KURT HJORTSTAM 273
Scytalidium japonicum, a new species, the causal agent of cattle bronchiolitis.
SHUN-ICHI UDAGAWA, KIYOSHI TOMINAGA and TAKAFUMI HAMAOKA 279
Alternaria themes and variations (22-26) .. EMORY G. SIMMONS 287
NOTICE: Deadline for proposals to amend the Code of Botanical Nomenclature at the XIV International Botanical Congress 309
Revue des Livres ..... G. L. HENNEBERT 311

Henri ROMAGNESI; Wolfgang MARGRAF; Klaus-Dieter JAHNKE; R. AGERER; Jacques BERTHIER; Norberto GARRIDO; Martha SINGER; Isabelle I. TAVARES; Harold H. BURDSALL, Jr.; E.J.H. CORNER; Heinz D. OSIEWACZ; Rainer DICKHARDT; H. David THURSTON; D.M. PORTER, D.H. SMITH & R. RODRIGUEZ-KABANA; D.J. HAGEDORN; E. KITS VAN WAVEREN; Enver Tali CETIN; Kazuo KOMAGATA; Jean E. CLARK & Edson C. SETLIFF; Wolfgang BRANDENBURGER; P.F. CANNON, D.L. HAWKSWORTH & M.A. SHERWOOD-PIKE; Niels BURGERS, Ron COCKCROFT & Dammes DE JONG; BULLETI DE LA SOCIETAT CATALANA DE MICOLOGIA; FICHAS TÉCHNICAS; AGARICA, MYKOLOGISK TIDSSKRIFT

No. 2 April-June 1986

Nematoctonus and the tribe Resupinateae in Ontario, Canada. R. G. THORN and G. L. BARRON 321
New species **Dekkera custersiana** and **D. lambica**, teleomorphs of **Brettanomyces** ..... FWU-LING LEE and SHUNG-CHANG JONG 455
Studies in the genus **Phoma**. V. Concerning **Phoma pomorum**. JAMES F. WHITE and GARETH MORGAN-JONES 461
Studies in tropical Corticiaceae (Basidiomycetes) VI: A new species of **Steccherinum** from Brazil. KURT HJORTSTAM and VERA LUCIA RAMOS BONONI 467
Taxonomy of the **Fomitopsis rosea** complex (Aphyllophorales, Polyporaceae) ... J. CARRANZA-MORSE and R. L. GILBERTSON 469
Observation d'un **Taphrina** parasite sur **Polystichum setiferum** (Forskall) Moore ex Woynar en France .... ALAIN SCHNEIDER 487
Thyrea polyglossa and **Thyrea divergens** sp. nov. AINO HENSSEN 493
The genus **Arthroderma** and its later synonym **Nannizzia**. I. WEITZMAN, M. R. McGINNIS, A. A. PADHYE and L. AJELLO 505
A note on the typification of **Guignardia** ..... JOHN BISSETT 519
Valseutypella multicollis sp. nov. J. CHECA, G. MORENO and MARGARET E. BARR 523
Illinois fungi XII. Fungi and myxomycetes from wood and leaves submerged in southern Illinois swamps. C. A. SHEARER and J. L. CRANE 527

Some new and noteworthy fungi (Aphyllophorales, Basidiomycetes) from Iguazu, Argentina.
KURT HJORTSTAM and LEIF RYVARDEN 539
Lasiosphaeriopsis stereocaulicola.
O. ERIKSSON and R. SANTESSON 569
Biogeography of fungal ectoparasites of termites.
MEREDITH BLACKWELL and WALTER ROSSI 581
Flavoparmelia, a new genus in the lichen family Parmeliaceae (Ascomycotina) ..... MASON E. HALE, Jr. 603
Russula vesicatoria and **Russula angustispora** sp. nov., two confusing species of **Russula** subsection **Lactarioideae.**
GERALD F. BILLS 607
Acaulospora delicata sp. nov. - an endomycorrhizal fungus from Arizona.
CHRISTOPHER WALKER, C. M. PFEIFFER and H. E. BLOSS 621
Botryohypoxylon gen. nov. and its anamorph, **Iledon** gen. nov. ..... GARY J. SAMUELS and JACK D. ROGERS 629
Notes on Hygrophoraceae IX: **Camarophyllopsis** Herink, an older name for **Hygrotrama** Sing. ..... EEF ARNOLDS 639
Ophiovalsa in the Pacific northwest.
DEAN A. GLAWE and JON D. JENSEN 645
NOTICE: A change in editorial policy for long papers 657

Author INDEX 659
INDEX to fungous and lichen taxa 663
Errata 671
Reviewers 673
MYCOTAXON publication dates, volumes 24 and 25(1) 673

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MYCOTAXON

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Volume XXV January-March 1986 No. 1

CONTENTS

Notes on Entomophthorales (Zygomycotina) collected by T. Petch: **Erynia anglica** comb. nov. and **Erynia coleopterorum** ..... ISRAEL S. BEN-ZE'EV 1
A new entomogenous species of **Cordyceps: Cordyceps ithacensis** sp. nov. STANISŁAV BAŁAZY and ANNA BUJAKIEWICZ 11
On **Dinemasporium adeanum** Petrak. T. R. NAG RAJ and BRYCE KENDRICK 15
Taxonomic notes on **Diatrypella discoidea, Diatrypella decorata,** and **Diatrypella placenta** ..... DEAN A. GLAWE 19
The "**Pleurotus silvanus**" complex ..... R. G. THORN 27
Basidiomycetes that decay Gambel oak in southwestern Colorado: II. ..... J. PAGE LINDSEY 67
New species in the lichen family Parmeliaceae (Ascomycotina) ..... MASON E. HALE, JR. 85
Taxonomic concepts in the Endogonaceae: II. A fifth morphological wall type in endogonaceous spores. CHRISTOPHER WALKER 95
Marine Pythiaceae from decaying seaweeds in the Netherlands ..... A. W. A. M. DE COCK 101
A new sporocarpic species of **Acaulospora** (Endogonaceae). N. C. SCHENCK, JOYCE L. SPAIN and EWALD SIEVERDING 111
Some more observations on eastern Himalayan Helotiales. RAGHUNANDAN SHARMA, WOLF-RÜDIGER ARENDHOLZ and K. S. THIND 119
A corrected authors index for A Bibliographic Account of Exsiccatae Containing Fungi ..... DONALD H. PFISTER 141
The new species **Dekkera naardenensis,** teleomorph of **Brettanomyces naardenensis.** SHUNG-CHANG JONG and FWU-LING LEE 147
Tolypocladium, a synonym of **Beauveria** ..... J. A. VON ARX 153
Modification of Nobles' species code for identification of basidiomycete cultures ..... GEORGE P. CHAMURIS 159

[CONTENTS continued overleaf]

ISSN 0093-4666 *MYXNAE 25(1) 1-320 (1986)*

Published quarterly by MYCOTAXON, Ltd., P.O. Box 264, Ithaca NY 14851
For subscription details, availability in microfilm and microfiche, and availability of articles as tear sheets, see back cover

[CONTENTS continued]

Dermatiscum fallax (Physciaceae), a new lichen from southern Africa ..... FRANKLIN A. BRUSSE 161
On the anamorph of **Phillipsia crispata** ..... JOHN W. PADEN 165
Experiences in computerizing the National Fungus Collections' specimen label data ..... DAVID F. FARR 175
The ecological and geographical distribution of 108 species of macromycetes from the subtropical, evergreen, broad-leaved forests in China ..... HUI-CI TAN and REN-JIAN WU 183
Alternaria themes and variations (14-16) .. EMORY G. SIMMONS 195
Alternaria themes and variations (17-21) .. EMORY G. SIMMONS 203
Glomus maculosum sp. nov. (Endogonaceae): an endomycorrhizal fungus .. DIANE DOUD MILLER and CHRISTOPHER WALKER 217
Four new Japanese species of the Ceratostomataceae (Ascomycetes). YOSHIKAZU HORIE, SHUN-ICHI UDAGAWA and PAUL F. CANNON 229
Notes on hyphomycetes. LI. **Kameshwaromyces**, a new foliicolous, sooty mold-like genus from Madhya Pradesh, India. KAMAL, R. V. VERMA and GARETH MORGAN-JONES 247
Arctoparmelia, a new genus in the Parmeliaceae (Ascomycotina) ..... MASON E. HALE, JR. 251
Hormotheca for species of **Coleroa** with hemispherical ascomata ..... MICHAEL CORLETT and MARGARET E. BARR 255
Taxonomic notes on some powdery mildews of various genera. UWE BRAUN 259
Typification of **Dimeromyces isopterus** (Laboulbeniales). JAMES W. KIMBROUGH 271
Notes on Corticiaceae (Basidiomycetes) XIV ... KURT HJORTSTAM 273
Scytalidium japonicum, a new species, the causal agent of cattle bronchiolitis. SHUN-ICHI UDAGAWA, KIYOSHI TOMINAGA and TAKAFUMI HAMAOKA 279
Alternaria themes and variations (22-26) .. EMORY G. SIMMONS 287
NOTICE: Deadline for proposals to amend the Code of Botanical Nomenclature at the XIV International Botanical Congress 309
Revue des Livres ..... G. L. HENNEBERT 311

[MYCOTAXON for October-December 1985 (24: 1-540) was issued December 11, 1985]

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A major error occurred in the printing of the spine for volume 24, wherein the spine text for volume 23 was reprinted by error. It should have read:

MYCOTAXON 24: 1-540 + i-iv, INDICES. OCTOBER-DECEMBER 1985

Errata of
Key for
1-20

MYCOTAXON

Cumulative Index for Volumes I-XX (1974-1984)

Richard P. Korf
Susan C. Gruff

Tip-in Pages (pp. 159, 227) of
ERRATA AND OMISSIONS
(Taxon Index)

Book published February 1985
Errata published November 1985

146, 148; 15: 234
anceps 12: 152
annonae 12: 154
aurantii 7: 174
belonospora 12: 154, 156
var. unicaudata 12: 154
briardii
var. longipila 12: 154
cerea 12: 146, 148, 154, 157
coccicola 7: 164, 167, 177
coccorum 7: 163, 178
cupularum 12:.154
cylindrothecia 12: 146, 152, 153
episphaeria 12: 154
erinacea 7: 181
everhartii 12: 154, 156
larvaespora 7: 171
muscivora 8: 494
palicoureae 5: 59
palmarum 12: 156
paludosa 12: 151
puiggarii 8: 325, 327
tetraspora 7: 174, 176, 177
trichospora 8: 321, 328, 498; 12: 146
vernoniae 8: 549
OPHIOSPHAERELLA 11: 1, 2, 52-54, 60, 61, 68, 70, 72-74, 81, 82, 94, 99
erikssonii 11: 1, 70, 73, 74, 78
graminicola 11: 70, 72, 78
herpotricha 11: 31, 37, 52, 54, 56, 58, 61, 69, 70, 73, 74-78, 82, 99, 102
leptosperma 11: 54, 77, 78, 99
stipae 11: 44, 78, 80-82
williamsii 11: 45, 78, 81,.82
OPHIOSPHAERIA 11: 1, 2, 8, 67, 68
chaetophora 11: 3, 8
gracilis 11: 3, 5, 6, 27
tenella 11: 3-6, 8, 67
OPHIOSTOMA 12: 48-52, 60, 65, 86; 15: 227, 460
(rank ?) Ips 12: 49
(rank ?) Minuta 12: 49
(rank ?) Pilifera 12: 49
pilifera 12: 53
OPHIOSTOMATALES 12: 48
OPHIOTRICHA 11: 84
OPHIOTRICHIA 11: 1, 2, 84
ORAMASIA 18: 159, 162
hirsuta 18: 161, 162
var. hirsuta 18: 162
var. ramosa 18: 162
ORBICULA 3: 388; 4: 545, 548, 549; 12: 58, 59, 64, 65, 71, 87
ORBILIA 2: 124; 4: 340; 8: 495; 12: 313, 314, 323, 334, 358, 359; 16: 107, 112
assimilis 8: 336
gelatinosa 4: 340, 341
luteorubella 16: 112
piloboloides 16: 107, 108, 110, 112, 113
xanthostigma 16: 112
ORCADELLA
pusilla 10: 313
ORCHESELLARIA 20: 260, 268, 270, 273
latessi 20: 260
mauguioi 20: 259, 260, 270, 272
pelta 20: 259, 260, 266, 268, 270, 273
podurae 20: 259, 260
ORPHANOMYCES 6: 457, 461, 462
arcticus 6: 462
ORPHELLA
coronata 17: 214
ORPHNIOSPORA
atrata 18: 178
OSMOPORUS 7: 342; 8: 224, 228; 12: 382; 20: 564
odoratus 7: 342; 12: 382, 403
subsp. americanus 19: 138
OSORIOMYCES 13: 412, 416-418
rhizophorus 13: 412, 413, 414, 417
OSTEINA 7: 339; 12: 381
obducta 7: 339; 12: 381, 403
OSTRACODERMA 19: 219; 19: see 219-270
OSTREICHNION 3: 81-83, 88
americanum 3: 81, 83; 9: 33
curtisii 3: 81, 83, 84, 86-88
europaeum 3: 81
nova-caesariense 3: 81, 83, 84
sassafras 3: 81-83, 84; 9: 33
OSTREION 3: 81
americanum 3: 81-83
OSTREOLA 3: 82
consociata 3: 82
OSTROPA 5: see 273; 6: 222
cinerea
var. virens 5: 70; 6: 222
mellea 5: 131
virens 5: 70
OTIDEA 7: 99
abietina 7: 83
alutacea 7: 83
auricula 7: 79
bufonia 7: 83
concinna 7: 83
grandis 7: 83; 8: 343
leporina 7: 83
onotica 7: 83
smithii 7: 83
OTTHIA 15: 355; 20: 19
alnea 20: 27
ambiens 15: 355
pruni 14: 215
OUDEMANSIELLA 9: 117, 119, 120
badia 15: 62
brunneomarginata 15: 62
canarii 7: 243
hygrophoroides 15: 62
longipes 15: 63; 17: 428, 431
nigra 15: 62
platensis 7: 243
pseudoradicata 15: 62
radicata 9: 156, 254, 255
renati 15: 62
xeruloides 15: 62
OVADENDRON 4: 391, see 487
sulphureo-ochraceum 4: 392, see 487
OVULARIA 9: 417, 425; 10: see 57
monosporia 8: 393
OVULARIOPSIS 11: 346
OVULINA
azaleae 9: 397
perplexa 9: 422
OVULINIA 1: 148
OXYDONTIA
chrysorhizon 7: 12
OXYPORUS 20: 360
cervino-gilvus 13: 185; 20: 150, 338, 350
corticola 20: 354, 360
latemarginatus 12: 475, 494
populinus 12: 494

OMISSIONS and a few errata, mostly from volume 5

ABSCONDITELLA 5: see 271
ACAROSPORA 5: 34
ACERBIA
  bacillifera 5: 106
ACROSPERMUM 5: see 271
AGRYRIUM delete entry
AGYRIELLA 5: see 271
AGYRIOPSIS 5: see 271
AGYRIUM 5: see 271; 12: 296
AMPHISPHAERIA
  salicicola 5: 49
APOSTEMIDIUM 5: 4, 40, 86
ARACHNOPEZIZA 5: 86
ARTHONIA 5: 64
ASTERISTION 5: 50
ASTERONAEVIA 5: see 271
BACIDIA 5: 15
BELONIDIUM
  albo-rubrum 5: 181, 182
BISBYELLA 5: 39, 44, 108
BRIARD'A 5: see 271
BUELLIA 5: 26
CALICIUM 5: 109
CALLORIA
  tithymalina 5: 256
CARESTIELLA 5: see 271
CELLULOSPORIUM 5: 142
CENANGIUM 5: 2
CERION 5: see 271
CEUTHOSPORA 5: 60
CHAILLETIA 5: see 271
COCCOMYCES 5: 153, 256
COCCOPEZIZA 5: see 271
COCHLIOBOLUS 5: 13
COENOGONIUM 5: 27
COLPOMA 5: 45, 153, 196
CONOTREMA 5: see 271
CONOTREMOMYCES 5: 46
CRYPTOMYCES 5: see 271
CYANOSPORA 5: see 271
CYATHICULA
  coronata 5: 8, 9
CYCLEDIUM 5: see 271
CYCLOSTOMA 5: see 271
CYLINDRINA 5: see 271
CYPHELIUM 5: 109
CYSTOTRICHA 5: 49
DASYSCYPHUS 5: 94, 182
DELPONTIA 5: see 271
DIDYMASCINA 5: 49
DIDYMOSPHAERIA 5: 49
DIMERELLA 5: 27, 89
DIPLOCRYPTIS 5; see 272
DIPLONAEVIA 5: see 272
DIPLOSCHISTES 5: see 272
DITIOLA 5: 2
DUEBENIA 5: 44
DURELLA 5: see 272
EPICHLOE
  typhina 5: 24, 39
ERINELLA
  bicolor 5: 58, 59
EUPROPOLELLA 5: see 272
EUPROPOLIS 5: see 272
EUSTEGIA 5: 83
FABRELLA 5: see 272
FLAMINIA 5: 51
FUSIDIUM
  violaceum 5: 42
GLOEOLECTA 5: 17, 25, 27, 31
GLOMERELLA 5: 59
GLONIUM
  striola 5: 87
GLYPHIUM 5: 28
GRAPHIS 5: see 272
GYALECTA 5: 27, 32, 89
HABROSTICTIS 5: see 272
HAPLOGRAPHIUM 5: 224
HELMINTHOSPORIUM 5: 13
HEMIPHACIDIUM 5: 64
HYALOSCYPHA 5: see 272
HYPODERMA 5: 26, 52
HYSTERIUM 5: see 272
HYSTEROPEZIZA
  atrata 5: 152
HYSTEROPEZIZELLA 5: see 272
HYSTEROSTEGIELLA 5: see 272
IRYDYONIA 5: see 272
JANSEELLA 5: see 272
KARSCHIA 5: 26, 138
LAQUEARIA 5: see 272
LASIOSTICTIS 5: see 272
LECANORA
  subfuscata 5: 15
LECIDEA
  urceolata 5: 45
LEOTIA
  truncorum 5: 86
LEPTOCREA 5: see 272
LEPTOSPHAERIA 5: 165
LEPTOSPORA 5: 24
LEPTOSPORIUM 5: 86
LEPTOSTROMA
  scripta 5: 64
LICHEN 5: see 272
LICHENOPSIS 5: see 272
LINDAUELLA 5: see 272
LOPHODERMIUM 5: 64
LYCOPERDON 5: see 272
MELANOSTROMA 5: see 272
MELITTOSPORIELLA 5: see 272
MELITTOSPORIUM 5: see 272
MEROSTICTIS 5: see 272-273
MICROPEZIZA
  subvelata 5: 51
MOUTONIELLA 5: see 273
MYCOGLAENA 5: 28, 63
NAEMACYCLUS 5: see 273
NAEVALA 5: 29, 64
NAEVIA 5: see 273
NAEVIELLA 5: see 273
NAEVIOPSIS
  tithymalina 5: 256
NANOSTICTIS 5: see 273
NECTRIA
  verrucosa 5: 167
NEOPHACIDIUM 5: 63
NIPTERA
  macrospora 5: 72
OCELLARIA 5: see 273
OCELLULARIA 5: see 273
ODONTOTREMA 5: see 273
OPHIOBOLUS 5: 83
OPHIOGLOEA 5: 86
OPHIONECTRIA
  palicoureae 5: 57-59
OSTROPELLA 5: see 273
PARMELIA
  valenzueliana 5: 81
PATELLARIA 5: see 273
PATINELLARIA 5: 49
PEZICULA 5: see 273
PEZIZA 5: see 273
PHACIDIUM 5: see 273
PHAEOBOLUS 5: 72
PHAEOTREMA 5: 50, 52, 203
PHANEROMYCES 5: see 273
PHRAGMONAEVIA 5: see 273
PLACUNTIUM 5: 85
PLATYGLOEA
  disciformis 5: 256
PLATYGRAPHA 5: see 273
PLATYSTICTA 5: see 273
PLEIOSTICTIS 5: see 273
PLEOSPORA
  herbarum 5: 78
PLOETTNERA 5: 29, 73, 74
POLYBLASTIOPSIS 5: 63
POLYSTIGMA 5: 52, 57
PRAGMOPORA
  amphiloba 5: 251
PROPOLINA 5: see 273
PROPOLIOPSIS 5: see 273
PROPOLIS 5: see 273-274
PROPOLOMYCES 5: see 274
PSEUDOPEZIZA
  atrata 5: 152
PSEUDOSTICTIS 5: see 274
PYRENOPEZIZA 5: see 274
PYRENOTROCHILA 5: 81
RAMONIA 5: see 274
RHABDOCLINE 5: 64
RHAPHIDOSPORA
  oenotherae 5: 115, 117
RHYTISMA 5: see 274
SARCOTROCHILA 5: 81, 83
SCHMITZOMIA 5: see 274
SCLERODERRIS 5: 251
SCLEROGLOSSUM 5: 38
SCLEROTIUM
  album 5: 149
SCOLIOCARPON 5: see 274
SOLENIA
  fasciculata 5: 180
SPHAERIA 5: see 274
SPHAEROBOLUS 5: see 274
SPHAEROLINA 5: see 274
SPHAEROPEZIA 5: see 274
STEGIA 5:see 274
STEGOPEZIZA 5: 29, 83
STEGOPEZIZELLA 5: 82, 83
STICTIS
  (rank?) Stictes verae 143
STICTOPHACIDIUM 5: see 276
STICTOSTROMA 5: 85
THELOCARPON 5: 24
THELOPSIS 5: see 276
THELOTREMA 5: 81, 169
THERRYA 5: see 276
TREMELLA 5: see 276
TROCHILA 5: see 276
TUBERCULOSTOMA 5: see 276
TYMPANIS 5: see 276
VERRUCARIA 5: see 277
VIBRISSEA 5: see 277
XYLOGLOSSUM 5: 38
XYLOGLYPHIS 5: 87
XYLOGRAMMA 5: see 277
XYLOGRAPHA 5: see 277
XYLOPEZIA 5: see 277

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ISBN 0-930845-00-5 $17.50

MYCOTAXON

Vol. XXV, No. 1, pp. 1-10 January-March 1986

NOTES ON ENTOMOPHTHORALES (ZYGOMYCOTINA) COLLECTED BY T. PETCH: *ERYNIA ANGLICA* COMB. NOV. AND *ERYNIA COLEOPTERORUM*

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ABSTRACT

Entomophthora anglica, a little known entomopathogen of *Agriotes sputator*, was found to possess uninucleate, bitunicate conidia and is herein transferred to the genus *Erynia* as *Erynia anglica* comb. nov. Furthermore, the morphology and dimensions of its conidia, resting spores and pseudorhizomorphs were found to coincide with those of a more recently discovered entomopathogen of *A. sputator*, *Erynia elateridiphaga*. The latter is herein considered as a junior synonym of *E.anglica*. The conidia of *Erynia coleopterorum*, another entomopathogen of Coleoptera, were also found to be uninucleate and bitunicate, thus ascertaining its place in this genus.

T. Petch surveyed for and collected numerous entomogenous fungi, most of which were described in his series "Notes on entomogenous fungi" published for almost three decades until 1948. During that time and until recently, entomogenous Entomophthorales were classified in three genera: *Entomophthora* Fresenius, 1856; *Empusa* Cohn, 1855, *sensu stricto* Nowakowski, 1883; and *Massospora* Peck, 1879.

The description of *Entomophthora anglica* Petch (1943) included only conidial dimensions and general shape, and the possession of rhizoids and conidiophores coalescing over parts of the host's body. Generic features such as the detailed morphology of conidiophores, number of nuclei in conidia and the conidial wall structure were not mentioned. Unmentioned as well were the structure of rhizoids and the presence or absence of capilliconidia, resting spores and pseudocystidia. The type occurred on an unidentified beetle "?*Plateumeris*", while other hosts were adults of *Agriotes sputator*, *Lochnoea suturalis*, and *Cantharis* sp.

Petch described in the same article (1943) the conidial stage of what he assumed to be another entomogenous fungus originally described

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by him earlier from resting spores and rhizoids only, *Entomophthora coleopterorum* Petch (1932). The conidial stage was characterised by long, narrow oval conidia, tapering cystidia, and a number of pseudorhizomorphs ("fascicles of rhizoids"), and attacked a coleopterous larva and *Sitones flavescens* adults. Petch's assumption about the conspecificity of the two stages was based on the similarity of the pseudorhizomorphs and attack of coleopterous hosts.

Recent classifications of the Entomophthorales follow the Batkoan classification in using generic-level criteria such as the structure and function of conidiophores, and the conidial nuclear number and conidial wall structure (for a review of Batkoan classifications see Ben-Ze'ev and Kenneth, 1982a). *Entomophthora anglica* could not be accommodated in any of the genera accepted by recent classifications (Remaudière & Hennebert, 1980; Remaudière & Keller, 1980; Humber and Ben-Ze'ev, 1981) due to lack of relevant characters in its description. Ben-Ze'ev and Kenneth (1982a) placed this species in *Entomophthora sensu lato*, a group devoid of generic status, proposed especially for such incompletely described species. *E.coleopterorum*, however, despite missing information on its conidial nuclear number and wall structure, was tentatively transferred to the genus *Erynia* Nowakowski, 1881, emend. Humber & Ben-Ze'ev (Humber and Ben-Ze'ev, 1981). Its transfer was based on the conjecture of characters described by Petch (1943) and known as characteristic of *Erynia* only.

This study, based on a reexamination of Petch's specimens of *E.anglica* and *E.coleopterorum*, aims to clarify the taxonomic position of the first fungus and to ascertain that of the second.

MATERIALS AND METHODS

The following specimens from the T. Petch collection were kindly lent by The Herbarium, Royal Botanical Gardens, Kew: R 1224 (*Entomophthora anglica* Petch, TYPE, coll. H. Barnes per W.G. Branley, Pickering, 6 June, 1938); R 775 (*Entomophthora anglica* Petch, on a beetle, Hornsea, 14 July, 1931); R 1228 (*Entomophthora anglica* Petch, on *Lochnoea suturalis*, Edinburgh, R.W.G. Dennis, 3 June, 1939); R 1039 (*Entomophthora anglica* Petch, on *Agriotes*, Canbs., Summer 1933); R 748 (*Entomophthora anglica* Petch, on *Agriotes*, Canbs., 3 May, 1931); R 757 (*Entomophthora coleopterorum* Petch, TYPE, on beetle {slide only} Holt House Wood, 12 June 1931); R 993 (*Entomophthora coleopterorum* Petch, Lartington, 16 September, 1933); R 1038 (*Entomophthora coleopterorum* Petch, on *Sitona flavescens*, Wick., 10 October, 1927 {specimen and slide}). All of Petch's specimens, unless otherwise stated, were packets containing dried insect and fungal material.

Another specimen containing dried insect and fungal remnants, including elytra of *Agriotes sputator*, was sent by Prof. G. Turian of the University of Geneva, Switzerland, at the request of the author to examine material of *Entomophthora carpentieri* Giard (as described by Turian, 1957).

Microscope slides were prepared from small pieces dissected from dried specimens. Mounting and staining media were lacto-phenol, lactophenol cotton blue (LPCB) and Zirkle's acetocarmine (Lee, 1950) for staining nuclei. Conidial measurements were accomplished with a divided ocular, calibrated with a stage micrometer so that each division

= 2.3µm, with an objective magnifying X 40 and ocular X 15.

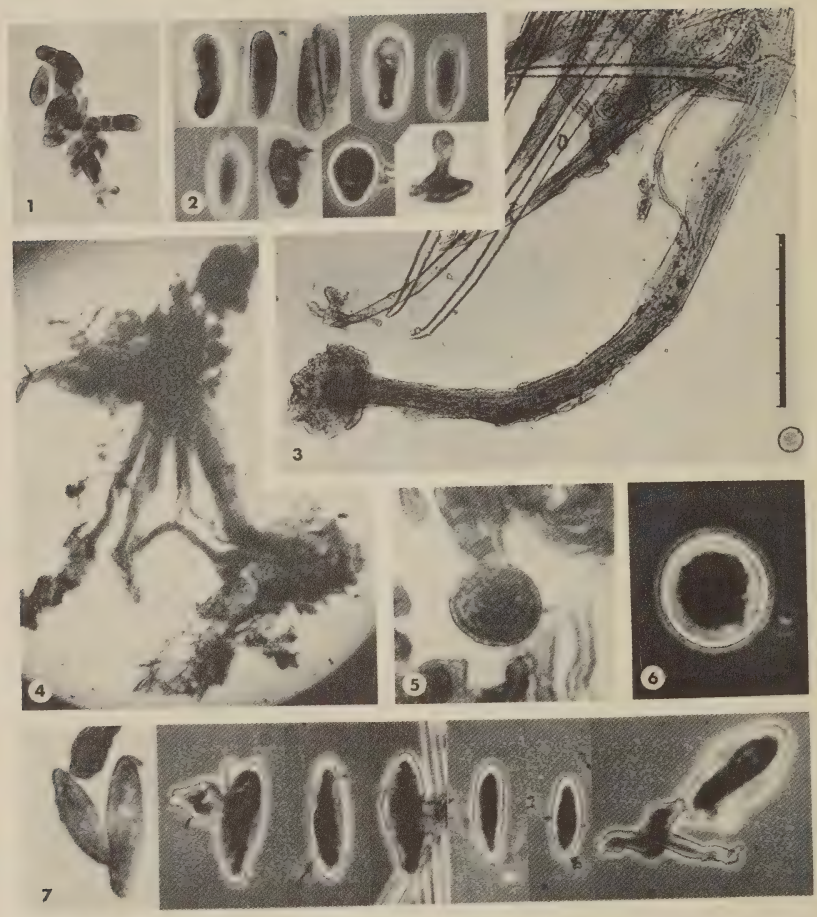
RESULTS

Two different species of *Erynia*, as defined by Humber and Ben-Ze'ev (1981), were found in Petch's *"Entomophthora anglica"* material. Conidia in the TYPE, R 1224, and in exsiccata nos. R 748 and R 1039 annotated *Agriotes* (*sputator*, as identified in Petch, 1943) resembled in shape *Erynia radicans* (Brefeld) Humber, Ben-Ze'ev & Kenneth in Humber and Ben-Ze'ev (1981) (Figs. 1,2). This fungus will be referred to below as *Erynia anglica*. Conidia in exsiccatum R 775 annotated "beetle" resembled in shape *Erynia nouryi* Remaudière & Hennebert (1980). This second species, which was absent in the type material of *E.anglica*, and did not match Petch's (1943) description of the latter, will be described elsewhere (Ben-Ze'ev, in preparation) as a new species, *Erynia suturaliis*.

In microscope slides (deposited at Kew) prepared by the author from Petch's exsiccata nos. R 1224 (*E.anglica* TYPE), R 748 and R 1039, there were relatively few conidia and the dried material was in a rather poor condition. Measurements of 72 conidia (combined from slides prepared from all three exsiccata) gave a total range of 16.7 - 33.4 X 8.0 - 13.8 µm. Some of the conidia observed had partially detached outer walls. All conidia observed had one, centrally located, ellipsoidal or spherical nucleus and a large vacuole located between nucleus and papilla — some conidia had a second, apical vacuole as well. Most ellipsoidal nuclei measured 4.6 X 6.8 µm and most spherical ones were 4.6 - 6.8 µm in diameter (stained with LPCB, viewed under phase contrast). The proportional papillar width of conidia (papillar width X 100/ conidial width) averaged 67%. Absolute papillar width was 5.2 - 7.5 µm ($\bar{x}$=6.4µm, s= 0.6 µm, n= 31). Absolute papillar length was very variable: 1.2 - 4.6 µm, and the longest papillae appeared to be associated with the less -well preserved conidia. It seems, therefore, that an average would be meaningless. One of the conidia observed was broad-pyriform (Fig. 2, lower row), uncharacteristic, and resembled *Erynia neopyralidarum* Ben-Ze'ev (1982). In some conidia the papilla was excentrically tilted (Fig. 2, upper left corner). Conidiophores appeared to be digitately branched, but could not be described as such with certainty due to their poor preservation. Pseudocystidia and capilliconidia, both unmentioned by Petch (1943), were not found.

Resting spores, unmentioned by Petch as well, were nevertheless found in his exsiccata nos. R 1224 (TYPE) and R 748. They measured 27.6 - 34.5 µm in diameter, with a wall thickness of 1.2 - 2.3 µm (Figs. 5,6). The shape, dimensions and length/ width (L/W) ratio of the largest conidia of *E.anglica*, as well as the dimensions of its resting spores and the morphology of its pseudorhizomorphs (Figs. 3,4) coincided very well with those of a well-described fungal pathogen of *Agriotes sputator, Erynia elateridiphaga* (Turian) Humber, Ben-Ze'ev & Kenneth in Humber and Ben-Ze'ev (1981). Conidial and resting spore dimensions of these species are compared in Table 1.

The *Entomophthora coleopterorum* material examined was found in very poor condition. Slides prepared from exsiccatum R 1038, as well as a slide prepared some years ago by S. Keller, contained no conidia or other recognizable structures except for disintegrating pieces of pseudorhizomorphs and mycelial debris. Shrunken and otherwise distorted conidia were present in slides prepared from exsiccatum R 993, together



Figs 1-6: Erynia anglica (=E.elateridiphaga) *from T. Petch's exsiccata. Figs 2-6 stained with LPCB. Bar (in fig.3) represents 50 µm in Figs 2, 5 and 6; 100 µm in Fig.1; 200 µm in Fig.3; and 500 µm in Fig.4.*

1. *Group of conidia, primary and secondary (acetocarmine).*
2. *Primary conidia (upper row) and secondary ones (lower row). The third conidium in the lower row has an aberrant shape, the extreme right one produces a tertiary conidium.*
3. *Pseudorhizomorph with discoid holdfast and scattered resting spores, one in the lower right corner.*
4. *Group of pseudorhizomorphs with holdfasts pointing downward.*

with many large pieces of pseudorhizomorphs and what could be imagined as ramified conidiophores. Seven conidia were in better shape than others and could be measured and photographed (Fig.7). The dimensions of these conidia were 27.6 - 41.4 X 9.2 - 15.0 µm, the most frequent length and width (3 out of 7) being 38.8 and 10.4 µm respectively. One of these conidia was clearly bitunicate (Fig.7, extreme right), and a few conidia were observed, under phase contrast optics, to be uninucleate (slides were stained with LPCB). Cystidia, as described by Petch (1943) were not observed, probably due to the condition of the material.

DISCUSSION

Entomophthora sphaerosperma Fresenius (now *Erynia radicans*) was recorded on *Agriotes obscurus* and *A.sputator* in the Soviet Union (Durnovo, 1935) without a description of its conidia. Turian (1957) described an attack of *E.sphaerosperma* Fres., subsp. *elateridiphaga* Turian on *A.sputator* in Switzerland. He proposed this subspecies on the grounds that its conidia were substantially larger than those of *E.sphaerosperma* found on leafhoppers (Homoptera) and on lepidopteran larvae. Remaudière et al.(1976) described in detail an attack of Turian's subspecies on *A.sputator*, and concluded that it deserved a full specific status, as *Entomophthora elateridiphaga*, which they left for Turian (1978) to propose formally. With the growing acceptance of the genus *Zoophthora* Batko (1964), *E.elateridiphaga* Turian became *Zoophthora elateridiphaga* (Turian) Ben-Ze'ev & Kenneth (1980). The realization that *Zoophthora* Batko, 1964, is a junior synonym of *Erynia* Nowakowski, 1881 (Remaudière & Hennebert, 1980) caused yet another transfer: *Erynia elateridiphaga* (Humber and Ben-Ze'ev, 1981).

Since its description by Turian (1957), *E.elateridiphaga* was compared to and found different from all known species of *Erynia* subgen. *Zoophthora* (Batko) Ben-Ze'ev & Kenneth (1982b)(=*Zoophthora* Batko, *sensu* Remaudière & Hennebert, 1980), and from *E.coleopterorum*, by various authors (Turian, 1957; 1978; Remaudière et al., 1976; MacLeod et al., 1979; Remaudière & Hennebert, 1980; Ben-Ze'ev, 1980; Ben-Ze'ev and Kenneth, 1980; 1981a; 1981b; Keller, 1980; Humber and Ben-Ze'ev, 1981). None of these authors mentioned *Entomophthora anglica*. From the rather large list of literature examined for classification purposes by the author (Ben-Ze'ev and Kenneth, 1982a; 1982b) it appears that the *E.anglica* material was largely ignored since Petch (1943) published its description. Waterhouse (1975) and Waterhouse and Brady (1982) mentioned this species and added information about "...cystidia ? long, narrow", undescribed by Petch (1943). As cystidia are absent in *E.elateridiphaga* and were not seen by me in Petch's *E.anglica* material on *Agriotes sputator*, the cystidia seen by Waterhouse (1975) match and were probably those of *Erynia suturaliis*(Ben-Ze'ev, in preparation) in Petch's material on *Lochnoea suturalis*.

←

5. *Young resting spore produced in mycelial mat.*
6. *Mature resting spore with multiple-layered wall.*

Fig. 7: Erynia coleopterorum *from T. Petch's exsiccata. Conidia stained with LPCB. The conidium at the extreme right shows a bitunicate wall. The "germ-tube" belongs to a hyphomycetous contaminant. Bar (in Fig.3) represents here 50 µm.*

A comparison of *E.anglica* conidial morphology (Fig.2) with that of *E.elateridiphaga* (Turian, 1978, Fig.2; Remaudière et al., 1976, Fig.7) and conidial dimensions (Table 1) leaves no doubt that *E.elateridiphaga* should not have been described and classified as a new species if the authors involved had been familiar with *E.anglica*.

Most of Petch's descriptions of Entomophthorales lacked any figures (drawings or photographs), and he apparently did not consider conidial dimensions as important enough. As a result, several of his descriptions had been found to be incorrect: *Entomophthora aprophorae sensu* Petch (1934) turned out to be a new species, *Erynia petchii* (Ben-Ze'ev & Kenneth) Ben-Ze'ev & Kenneth (1981b; 1982b). *Entomophthora pyralidarum* Petch (1937) turned out to have been described from two different species mixed in his material: *Conidiobolus apiculatus* (Thaxter) Remaudière & Keller (1980) and *Erynia neopyralidarum* Ben-Ze'ev (1982). The present study of the collection of *E.anglica* found it containing two different species as well.

When comparing (in Table 1) the dimensions of primary conidia attributed by Petch (1943) to *E.anglica* with those of *E.elateridiphaga*, and when comparing the dimensions of secondary conidia in the two descriptions, no clear similarity between the two is apparent. However, it is this author's opinion that Petch (1943) decided arbitrarily that conidia of *E.anglica* up to 21 µm long were secondary, and that those over 22 µm long were primary. For those familiar with the genus *Erynia* it is a well known fact that primary conidia and secondary ones of type Ia (as defined in Ben-Ze'ev and Kenneth, 1982a and b) overlap in their dimensions, e.g. the dimensions of primary and secondary conidia of *E.elateridiphaga* cited in Table 1 (rows 1 and 5). When comparing the total range found in this study for *E.anglica* (which accounts for primary, secondary and very probably tertiary conidia as well) with the total range given for *E.elateridiphaga*, (primary + secondary conidia), the similarity becomes difficult to ignore. As an exercise, the measurements of *E.anglica* were divided into "mostly primary conidia" and "mostly secondary conidia" (Table 1, rows 4 and 7, respectively) by applying the lower limits of length and L/W found in primary conidia of *E.elateridiphaga* by Remaudière et al.(1976)(Table 1, row 1). The obtained group of "mostly primary conidia" contained 36 of the 72 conidia measured, and its dimensions fit rather well those of *E.elateridiphaga*. The slightly larger width and consequently smaller L/W ratio are attributed to some secondary conidia included inevitably, because of their overlapping length. The group of "mostly secondary conidia" (row 7) fits only partly the dimensions of secondary conidia of *E.elateridiphaga* (row 5). Here the discrepancy is caused by the presence of smaller conidia, with smaller L/W ratios, assumed to be tertiary conidia. Such a conidium, apparently being produced by a secondary one, is photographed in Fig. 2 (lower right corner). Resting spores found in this study agree perfectly in their dimensions (Table 1, row 10) and appearance with those of *E.elateridiphaga* (rows 8 and 9). Consequently, the following new combination and synonymy are proposed:

ERYNIA ANGLICA (Petch) Ben-Ze'ev, emend. et comb. nov.

Basionym: *Entomophthora anglica* Petch, 1943, Trans. Br. mycol. Soc. 26:89.

Synonyms: *Erynia elateridiphaga* (Turian) Humber, Ben-Ze'ev & Kenneth in Humber and Ben-Ze'ev, 1981, Mycotaxon 13: 509.

Zoophthora elateridiphaga (Turian) Ben-Ze'ev & Kenneth 1980, Entomophaga 25:181.

Table 1. *Comparison of conidial and resting spore dimensions (in µm) of fungi considered as synonyms of* Erynia anglica.

	SOURCE	LENGTH (L) (min)- $\bar{x}$ -(max)	WIDTH (W) (min)- $\bar{x}$ -(max)	L/W RATIO (min)- $\bar{x}$ -(max)
		P R I M A R Y	C O N I D I A	
(1)	*Remaudière et al.(1976)* (E.elateridiphaga)	(24)-29.2 -(36) >27	(7)-8.7-9.7-(10) >8.5	(2.4)-3.2-(4.4) 3.0 - 3.6
(2)	*Turian (1978)* (E.elateridiphaga)	(?)- 29-32 -(?)	(?)- 9-10 -(?)	
(3)	*Petch (1943)* (E.anglica)	(22) - (27)	(11) - (13)	
(4)	*Present study: "mostly primary conidia" from Petch's material* (E.anglica)	(25.3)-27.6-(33.4)	(8.0)-9.8-(13.2)	(2.5)-2.9 -(3.5)
		S E C O N D A R Y	C O N I D I A	
(5)	*Remaudière et al.(1976)* (E.elateridiphaga)	(21)- 25 -(28)	(7)- 9.9 -(12)	(2)- 2.5 -(3.2)
(6)	*Petch (1943)* (E.anglica)	(18) - (21)	(10) - (11)	
(7)	*Present study: "mostly secondary" conidia from Petch's* E.anglica	(16.7)-22.0-(28.8)	(8.0)-10.7-(13.8)	(1.3)-2.2-(2.7)
		R E S T I N G	S P O R E S (DIAMETER)	
(8)	*Remaudière et al.(1976)* (E.elateridiphaga)	(27)-29.4-32.3-(34)		
(9)	*Turian (1978)* (E.elateridiphaga)	30		
(10)	*Present study from Petch's material, n=22*	(27.6)- 31.1 -(34.5)		

Entomophthora elateridiphaga Turian, 1978, Mitt. Schweiz. Entomol. Ges. 51:398.

The emendation merely combines Petch's (1943) formal description and the detais added in the present study with the more detailed descriptions given by Remaudière et al.(1976) and Turian (1978). The last two descriptions include data about capilliconidia and resting spores, unseen by Petch (1943) and are more accurate with regard to conidial

dimensions. *E.anglica* replaces the junior synonym *E.elateridiphaga* in the subgenus *Zoophthora*.

Petch (1943) compared *E.anglica* with *Entomophthora nebriae* Raunkiaer, now *Erynia nebriae* (Raunkiaer) Humber & Ben-Ze'ev (1981), which has "...conidia...28-37 X 10-13 µm, and ... pale brown, smooth, globose resting spores, 35-50 µm diameter, produced outside the body of the host." These conidial dimensions are quite close to those of *E.anglica (=E.elateridiphaga)*. *E.nebriae* differs from *E.anglica* in the different size, color and site of production of resting spores, and in having different hosts.

The transfer of *Entomophthora coleopterorum* to *Erynia* (Humber and Ben-Ze'ev, 1981) appears to be justified in the light of the present findings. A nomenclatural problem is, however, involved. Petch's connection of the resting spore stage with the conidial stage found in other, different hosts, was considered only as probable by Petch (1943) himself. No proof for this connection was ever found by Petch or others, nor could any further evidence be found in the present study, considering the condition of the exsiccata. If and when this assumed connection is disproved, the resting spore stage will retain the specific epithet *coleopterorum*, and the *Erynia* stage will have to be described as a new species.

Petch (1943) considered that *E.coleopterorum*, validly published, is probably the same as *Entomophthora carpentieri* Giard (1888), published without description and therefore invalid. Turian (1957) found and described a fungus which he also thought to be *E.carpentieri*. Giard (1888) did not describe his fungus except for the statement that it attacked *Agriotes sputator* and fixed the infected insects to the plants by means of pseudorhizomorphs emerging from the ventral junction of the prototho-rax and mesothorax and behind the metathoracic legs. Both Petch (1943) and Turian (1957) relied on the similarity of the pseudorhizomorphs to claim similarity or identity between the species they found and *E.carpentieri*. The examination, in the present study, of *E.carpentieri* material sent by Prof. G. Turian, revealed only resting spores, identical in morphology and dimensions with those of *E.anglica* found in Petch's material and with those described by Turian (1957; 1978)and by Remaudière et al.(1976) as *E.elateridiphaga*. If they indeed belong to *E.anglica*, their finding in material annotated by Turian "*E.carpentieri*" is understandable, considering that both fungi attack the same host during June in Switzerland, and that material with the two fungi was collected by the same person (i.e. Turian, 1957). As for the probable identity of Giard's *E.carpentieri*, the host could indicate, by conjecture, *E.anglica*, but not *E.coleopterorum*. The fungus described by Turian (1957) as *E.carpentieri*, with bifurcately branched conidiophores, pseudorhizomorphs and uninucleate, spherical conidia appears to be an unusual species of *Erynia*. The very unusual conidial shape (for *Erynia*) is no longer unique — *E.neopyralidarum* also has subglobose and globose conidia (Ben-Ze'ev, 1982, Fig.2). Turian's (1957) fungus was not reencountered since 1953 and it lacks a detailed and formal description, whether it is *E.carpentieri* or a new species.

ACKNOWLEDGMENTS

The courtesy of the Curator of The Royal Botanical Herbarium, Kew, U.K., and Prof. G. Turian of the University of Geneva, Switzerland, in lending me specimens for study is gratefully acknowledged. I also thank

Prof. R.G. Kenneth of the Hebrew university of Jerusalem for his constructive review of the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 11-14 January-March 1986

A NEW ENTOMOGENOUS SPECIES OF CORDYCEPS: CORDYCEPS ITHACENSIS SP. NOV.

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ABSTRACT

A new species, **Cordyceps ithacensis**, is described in **Cordyceps** subgenus **Eucordyceps**, section **Racemella** of Kobayasi's classification. It was found on a small dipteran larva of the family Erinnidae in the litter of a moist deciduous forest in the eastern United States.

Only one tiny stroma of a new **Cordyceps**, with its well-developed fertile part, has been collected in the course of mycocoenological studies performed on permanent plots in patches of riverside forests near Ithaca. This fungus was recorded as **Cordyceps** sp. in a list of species reporting these studies (Bujakiewicz, 1985) since its morphological features did not correspond with any of the hitherto described species. After more detailed study, the authors now consider it to be a new species, with the following description.

CORDYCEPS ITHACENSIS sp. nov. (Figs. 1-4)

The host body filled with a pseudosclerotium composed of irregularly ramose and densely arranged hyaline hyphae rather uniformly narrow, diam 2.0-4.0 mm, with some slightly inflated segments up to 4.5 mm wide. Stroma (Fig. 1) single, helically twisted at the base, bent above, cylindrical, 4.9 mm long and 0.6 mm wide, rough over nearly the whole surface, cinnamon-brown except for a lighter, smooth, narrow ring just below the head. The internal part of the stroma formed of dense, parallel hyphae 2.0-5.5 mm diam, thinnest in the center, with septa regularly distributed at approx. 30 mm intervals, light yellow-orange in mass. Superficial layer composed of oval to subglobose cells, 6.0-12.5 X 4.0-7.0 mm, with brownish, somewhat thickened walls (Fig. 2). Fertile portion terminal, globose, 1.3 mm diam, tuberculate from radially arranged pear-shaped, orange perithecia 685-860 X 385-510 mm, a little darker in colour near the ostioles, with the bases of the perithecia immersed in the stroma up to $\frac{1}{4}$ or $\frac{1}{2}$ of their total height. Perithecial walls

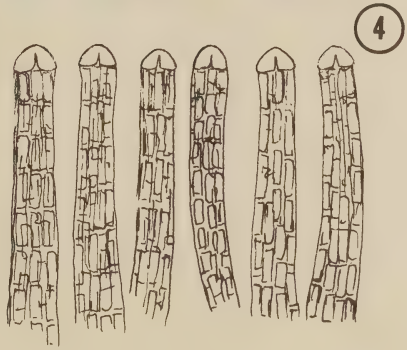
composed of oval, globose, or obtusely multiangular cells 6.0–9.0 µm in diam with light golden-yellow contents and light orange walls. Hyphae of the subhymenial layer very thin-walled, slightly branched, 2.0–4.0 µm wide. Asci (Fig. 3) cylindrical, 260–340 X 8.6–10.0 (–10.7) µm, with domed capitula obtuse triangular in outline (Fig. 4), 4.7–5.5 µm wide at the base and 3.1–4.0 µm high. Ascospores filiform, 1.7–2.6 µm wide, multiseptate, ascospore articuli cylindric, truncate at both ends or with imperceptibly obtuse angles, (6.0–) 6.7–10.1 (–12.4) X 2.0–2.6 µm.

In a dipteran larva of the family Erinnidae in the litter of a deciduous forest (**Ulmus/Fraxinus/Carya**) in Fall Creek valley, NE of Ithaca, New York, USA, collected 29 October 1982, leg. Anna Bujakiewicz. The holotype specimen is assigned the number 542 in the Herbarium (Mycological Collection) of the Department of Plant Ecology and Environment Protection, Adam Mickiewicz University, Poznań, Poland.

Corpus hospitis mycelio composito ex hyphis hyalinis dense aggregatis, irregulariter ramosis, plus minusque aequiangustatis diametro 2.0–4.0 µm cum inflatis partibus ad 4.5 µm impletum. Stroma unum paulo flexuosum in basa heliciforme, longitudine 4.9 mm et 0.6 mm crassum, cum terminali capite globose delineato diametro 1.3 mm. Stipes cylindricus, in tota longitudine praeter minimam partem sub ipso capite asper, cinnamomeo-fulvus, in supera parte pallidior. Stratus superficialis stipitis ex ovalis vel subglobosis cellulis dimensionibus 6.0–12.5 X 4.0–7.0 µm cum incrassatis fulvis membranis compositus. Interiorem partem formant paralleliter aggregatae hyphae tenuiparietales, diametro 2.0–5.0 µm, in intervallis ca 30 µm septatae, in centro tenuissimae. Pars fertilis tuberculata, composita ex radialiter ordinatis pyriformibus peritheciis dimensionibus 685–850 X 385–510 µm, aureorufis, obscurioribus apud ostiola. Parietes peritheciorum compositae ex dense aggregatis cellulis ovalis, globosis vel obtuse-multiangulatis, diametro 6.0–9.0 µm, paulo aureo-flavis, cum fortius coloratis membranis. Hyphae partis subhymenialis tenuae, flexuosae, paulo ramosae, diametro 2.4–4.0 µm. Asci cylindracei 260–340 X 8.6–10.0 (–10.7) µm cum capitulis obtuse triangularibus vel fere subglobosis, in basa 4.7–5.5 µm latis et 3.1–4.0 µm longis. Ascosporae filiformes 1.7–2.6 µm crassae, multiseptatae; articuli ascosporarum cylindricaei utrinque truncati, raro cum paulo obtusis angulis, (6.0–) 6.7–10.1 (–12.4) X 2.0–2.6 µm.

In larva dipterorum e familia Erinnidae in silva foliacea (**Ulmus–Fraxinus–Carya**) in rivi valli Fall Creek prope urbem Ithaca in regione New York, USA, die 29 mense Octobre, anno 1982 coll. Anna Bujakiewicz. Holotypus in collectione Departamento Ecologiae Plantarum et Universitat A. Mickiewicz in Posnaniam, numero 542 designatus.

In accordance with the systematic arrangement proposed by Kobayasi (1941), the above described species should be included in the subgenus **Eucordyceps**, section **Racemella**, subsection **Confertae**. His key indicates the closest species to be **C. kirkii** Cunningham. Yet both the macro- and micromorphology and the systematic position of the host indicate that species to be remote from the fungus described here. Subsequent revisional works as well as those with descriptions of new species (Mains, 1957, 1958, 1959; Koval, 1961, 1974; Kobayasi, 1977) contain no species which would correspond with the morphology of the one described above. The only species known hitherto as infecting dipteran larvae is **C. corallomyces** Möller, reported from Brazil and the east-Asian part of the Soviet



Figs. 1-4. **Cordyceps ithacensis** sp. nov. 1. General appearance. 2. Superficial layer of the stroma. 3. Asci. 4. Apices of asci.

Union (Möller, 1901; Kobayasi, 1941; Koval, 1974). The colour of its stromata and heads resembles C. **ithacensis**, but the lateral arrangement of perithecial agglomerations, sometimes multileveled, and the dimensions of all elements of the fructification make these two species readily distinguishable.

ACKNOWLEDGEMENTS

Deepest thanks and appreciation are extended to Dr. Richard P. Korf for offering the second author such a wonderful opportunity to do research in the United States and for his generous help and invaluable assistance during these studies. Without the financial assistance of the Anna E. Jenkins Postdoctoral Fellowship from the Cornell University Plant Pathology Herbarium and the support of the Brethren Service - Polish Agricultural Exchange Program these studies could not have been effected.

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MYCOTAXON

Vol. XXV, No. 1, pp. 15-18 January-March 1986

On *Dinemasporium adeanum* Petrak.

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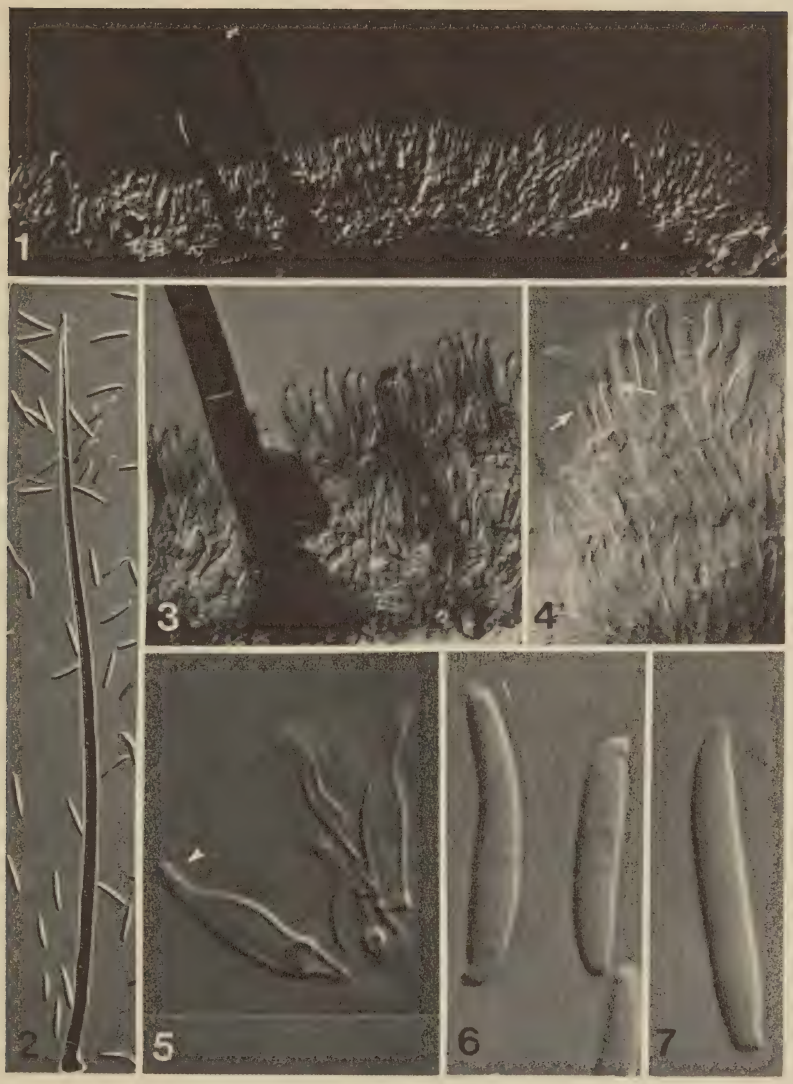
In his account of *Dinemasporium adeanum*, Petrak (1929) described the setose conidiomata as 'shallow bowl-shaped'; the conidiophores as lining the entire inner surface of the conidioma, simple, rod-shaped, more or less tuft-like at the base, strongly attenuated toward the apex and then more or less awl-shaped; and the conidia as 'narrow cylindric-fusiform, ... occasionally with 2-3, highly indistinct (transverse) septa, ... provided with a very short, indistinct, and almost evanescent, 1-2 µm long 'cilium' mostly only at one end.' Such characterization, and the fact that he did not mention the presence of an excipulum, would appear rather incongruous to those of us familiar with the morphology of a typical species of *Dinemasporium*; incongruous enough to raise a question about its correct identity.

Petrak (1929) applied the binomial to two collections, one on *Myrica faga* and the other on *Visnea mocanera*, both collected by Ade in 1926 in Tenerif, Canary Islands; he did not designate either of them as the nomenclatural type but included both in the protologue for the name. Through the courtesy of Dr. U. Passauer, we have examined both collections, distributed in 4 packets and housed in Petrak's Pilzherbarium in W. According to the labels on the packets, the 4 packets represent two sets of specimens -- one set acquired in 1971 and the other in 1973, but

each packet has been labeled as type and assigned a different acquisition number. All four specimens are syntypes in the broad sense; but, as required by ICBN, we have selected the specimen on Visnea mocanera in the packet bearing the number 10366 as the 'lectotype' of D. adeanum on the basis of the abundance and good condition of the fungal material. The remaining three collections (packets No. 10358, 26911 and 29613) are 'paralectotypes'. A careful scrutiny of all four specimens revealed the same fungus which, however, did not belong in Dinemasporium Lév., as Figs. 1-7, derived from the lectotype, and the following short description, derived from a study of all specimens cited, will show.

Conidiomata sporodochial, hypophyllous, scattered to gregarious, superficial to semi-immersed, setose, covered by agglutinated, pearly white or waxy yellow masses of conidia; basal stroma of 'textura globulosa' to 'textura angularis', cells brown and thick-walled, gradually merging with a linear series of darker cells above and then with a loosely aggregated tissue of pale brown cells from which the setae and conidiophores arise. Setae unbranched, cylindrical to subulate with a slightly bulbous base, erect, dark brown and thick-walled below, lighter and thin-walled towards the apex, up to 15-septate, 300-680 µm long, 6-13 µm wide at the base. Conidiophores branched, septate, pale brown to subhyaline, smooth, up to 50 µm long. Conidiogenous cells phialidic, lageniform to subcylindrical with recurved apices and flaring collarettes, hyaline, smooth, 10-17 X 2-3.5 µm. Conidia cylindrical to naviculate, apex obtuse, base narrow and truncate, with a short papillate protuberance on one side, straight or slightly bent, unicellular, hyaline, smooth, 13-30 X 2.5-3(-3.5) ($\bar{x}$ = 22 X 2.7) µm.

The setose sporodochial conidiomata, phialidic conidium ontogeny, the lageniform to subcylindrical phialides with recurved apices and flaring collarettes, and the unicellular conidia with the



Figures 1-7. Vermiculariopsiella immersa ex lectotype of D. adeanum in W. Fig. 1. Vertical section of a conidioma. Fig. 2. Seta. Figs. 3, 4. Enlarged views of the conidial hymenium. Fig. 5. Phialides. Figs. 6, 7. Mature conidia. (Figs. 1, 2: ca X 189; Fig. 3: a X 480; Fig. 4: ca X 750; Figs. 5-7: X 2000. Arrows = phialides with developing conidia; arrowheads = flaring collarettes).

short papillate protuberance at the base marking the point of attachment, are characteristics of Vermiculariopsiella Bender. The morphological features and the quantitative characters outlined above are reminiscent of V. immersa (Desm.) Bender as redescribed and illustrated by Nag Raj (1983). The only perceptible difference between specimens typifying these two names being a slightly wider range of conidial width (2-3.5 µm) in the lectotype of D. adeanum compared to 2-2.5 µm for V. immersa isotype. Such variation could well result from ecological responses of the fungus and hence we dispose D. adeanum Petrak as a synonym of Vermiculariopsiella immersa (Desm.) Bender.

We are indebted to Dr. U. Passauer, W for the loan of the specimens cited in this study and to Dr. W. I. Illman, Carleton University, Ottawa for a critical review of this note. We are grateful to the Natural Sciences and Engineering Research Council of Canada for underwriting this research.

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MYCOTAXON

Vol. XXV, No. 1, pp. 19-25 January-March 1986

TAXONOMIC NOTES ON **DIATRYPELLA DISCOIDEA, DIATRYPELLA DECORATA,** AND **DIATRYPELLA PLACENTA**

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After examining type, authentic, and additional specimens **Diatrypella placenta** is neotypified and **D. discoidea** var. **alni** is considered to represent the same species. **Diatrypella discoidea** is relegated to synonymy with **D. decorata. Diatrypella decorata** and **D. placenta** were found to be distinguishable by color of entostromatic pseudoparenchyma and host. Although it eventually may prove necessary to combine the two species, it seems better at present to maintain them as distinct since these differences are fairly consistent. Ultimately, cultural studies and tests of host ranges may be useful in making a final decision regarding the status of these taxa.

Herbarium abbreviations follow Hawksworth (1974). Where no herbarium is cited the collection is in my personal herbarium.

Diatrypella placenta Rehm, **Hedwigia** 21: 117. 1882.

=**Diatrypella discoidea** Cooke & Peck var. **alni** Rav. **ex** Ell. & Everh. (as var. **alni** Cooke), **N. Am. Pyren.**, p. 587. 1892.

[≡**Diatrypella discoidea** Cooke & Peck var. **alni** Rav., in Ravenel, Fungi americani exsiccati, Century II, no. 188, 1878. **Nomen nudum.**]

Teleomorph: Stromata erumpent through bark, pulvinate, circular to oval, upper surface nearly flat to slightly convex, (1-)1.5-3(-4) mm X 0.75 mm thick, often coalescing. Surface initially tan, later reddish-brown with black stellate fissures radiating from the black perithecial ostioles, becoming black and smooth when overmature. **Perithecia** in one layer, **ca.** 0.5 mm diam. Interior region between perithecial necks occupied by

mixture of white and reddish-brown pseudoparenchymatous tissue, appearing tan macroscopically. Ostioles distinctly three- to four-sulcate, circular, flattened. **Asci** spindle-shaped, long-stipitate, with refractive apical invaginations and slightly amyloid apical rings, multispored, **p. sp.** (35-)44-55(-62) X 4.4-6.6(-8) µm. **Ascospores** allantoid, slightly curved, subhyaline, (3-)4-5(-6) X 1(-1.5) µm.

Occurring on species of **Alnus.**

Anamorph: Not seen,

Comments: The type [S] apparently was immature when collected and is in very poor condition; no taxonomically significant characteristics remain. Fortunately, Rehm distributed this species in his "Ascomyceten" Exsiccati as no. 1984. Examination of specimens of that exsiccata [CUP, DAOM, K, M, MICH, NY, PAD] indicated that they are in good condition. Therefore, it seems better to regard the specimens distributed as no. 1984 of his exsiccatae as isoneotypes, rather than to attempt to fix the name for this fungus with the useless original type.

In the past, North American mycologists usually have used the above synonyms of **D. placenta** for this species. Glawe and Rogers (1984) cited Ellis and Everhart (1892) as listing Cooke as the authority for **D. discoidea** var. **alni.** As pointed out by Professor R. P. Korf (personal communication), this varietal name apparently was, in fact, first used by Ravenel for this fungus in his "Fungi americani exsiccati." Ravenel included no diagnosis on the packet label, but the name later was validated by Ellis and Everhart (1892).

The above description is based largely on one previously published for **D. discoidea** var. **alni** (Glawe and Rogers, 1984). Individual collections from throughout the world are quite similar, and as understood here, all known collections are from **Alnus** species. This fungus differs from the similar **D. decorata** in having a mixture of reddish-brown and white pseudoparenchyma within stromata, producing a macroscopically tan color rather than the usual white interiors of **D. decorata** stromata. In addition, the two fungi appear host-specific.

Specimens examined: AUSTRIA: Petrak, F., WSP 31398, VII.1939, Seehof bei Lunz, on **Alnus incana.** Rehm, H., S, TYPE, VIII.1874, Laengenthal near Kuehtai in Tyrol. (Oetz), on **Alnus viridis.** USA: COLORADO: Clements, F. E., and Clements, E. S., "Cryptogamae Formationum Coloradensium" no. 409, (ILL 10558), 17.VIII.1907, Wind River Canyon 2600 m, on **Alnus tenuifolia** [as "**Diatrypella aspera** (Fr.)

Nits."] IDAHO: Glawe, D. A., no. 79-15; no. 79-44 (WSP 66739), 79-298, 19.V.1979, Laird Park, Latah Co., on **Alnus** sp.; Rogers, J. D., WSP 56470, 16.VII.1964, farm wood lot on Rt. 95A 8 km SW intersection with Rt. 10, Kootenai Co., on **Alnus** sp. (as "**Diatrypella tocciaeanna** de Not."). OREGON: Brown, C. A., MICH, 4.XII.1925, Siskiyou Nat. Forest, Takilma, on **Alnus oregana** Nutt. (now known as **Alnus rubra** Bong.); Brown, C. A., MICH, 6.XII.1925, Siskiyou Nat. Forest, Takilma, on **Alnus oregana** Nutt. (now known as **Alnus rubra** Bong.); Denison, W. C., OSC 25088, 24.II.1968, Silver Falls, host not given, (as "**Diatrype disciformis**?"); Glawe, D. A., no. 80-229, 3.V.1980, Wildwood Recreational Area, near Sandy, Clackamas Co., on **Alnus rubra** Bong.; Glawe, D. A., no. 80-273 (WSP 66736), no. 80-315, 3.X.1980, Blue Pool Campground, near McCredie Springs, Lane Co., on **Alnus rubra** Bong.; Howell, C. R., det. S. C. Jong, WSP 57670, 23.VI.1963, 16 km NE Long Creek, Grant Co., on **Alnus** sp.; Waldron, H. M., Jr., WSP 51608, 23.VI.1963, 16 km N Long Creek, on **Alnus sinuata** (Regel) Rydb. (as "**Diatrypella discoidea** G. P. Clint. & Peck"). SOUTH CAROLINA: Ravenel, H. W., "Fungi americani exsiccati" no. 188, BPI, FH, PH, K, ISOTYPES, undated, Aiken, on **Alnus serrulata** (as "**Diatrypella discoidea** Cooke var. **alni**"). WASHINGTON: Glawe, D. A., no. 79-412 (WSP 66737), 16.IX.1979, 13 km S Forks, on Highway 101, Jefferson Co., on **Alnus rubra** Bong.; Glawe, D. A., no. 80-19, no. 80-21, no. 80-30, no. 80-43 (WSP 66738), no. 80-348, 11.VII.1979, Ike Kinswa State Park, Lewis Co., on **Alnus rubra** Bong.; Glawe, D. A., no. 79-282, 4.VIII.1979, no. 79-279, no. 80-49, no. 80-53, no. 80-92, 5.VIII.1979, Nooksack Campground, on Highway 542, Mt. Baker Nat. Forest, Whatcom Co., on **Alnus rubra** Bong.; Glawe, D. A., no. 79-311, 16.IX.1979, 3 km E Hoh, Hoh Trail, Olympia Nat. Park, Jefferson Co., on **Alnus rubra** Bong.; Glawe, D. A., no. 79-316, no. 79-395, no. 79-413 (WSP 66740), no. 80-1, no. 80-2, 15.IX.1979, North Fork Campground, Grays Harbor Co., on **Alnus rubra** Bong.; Hedgecock, C. G., det. J. Dearness, OSC 25460, 16.IV.1931, Mt. Summit to coast, Alladdin, on **Alnus tenuifolia** Nutt.; Jones, B. L., WSP 55335, 19.VII.1964, Big Spring Campground, NE 1/4 S 27 T9N R42W, Garfield Co., on **Alnus** sp. (as **Diatrypella tocciaena** de Not."); Suksdorf, W. N., WSP 27393, 21.VI.1894, White Salmon River, Klickitat Co., on **Alnus** (?) sp. USSR: Rehm, H., "Ascomycetes" no. 1984, VIII.1900, coll. Serebrianikow, CUP-F 3493, DAOM, K, M, MICH, NY, PAD, ISONEOTYPES, Schedenewo Prov., Jaroslawl., on **Alnus incana**; Tranzschel and Serebrianikow, "Mycotheca Rossica," VIII.1900, coll. Serebrianikow and Schestakow

(WIS), Schedenewo Prov., Jaroslawl., on **Alnus incana.**

Diatrypella decorata Nits., **Pyren. Germ.** p. 79. 1867.

=**Diatrypella discoidea** (Cooke & Peck) Sacc., Syll. Fung., Vol. I, p. 207. 1882.

≡**Diatrype discoidea** Cooke & Peck in Peck, **New York State Mus. Bull.**, No. 28, p. 71, 1876.

Teleomorph: Stromata erumpent through bark, pulvinate, transversely elliptical to oval, upper surfaces nearly flat, 1-2.5 mm across by 0.5-1 mm thick. Surface black to dark brown. **Perithecia** in one layer, **ca** 0.5 mm diam. Entostromatic parenchymatous region between perithecial necks usually white to yellowish white, infrequently with mixture of reddish-brown and white elements and appearing tan macroscopically. Ostioles well-developed, three- to four-sulcate, disc-shaped, flattened or rather prominent. **Asci** spindle-shaped, long-stipitate, with refractive apical invaginations and inamyloid apical rings, multispored, agglutinated; size (**p.sp.**) given by Nitschke (1867) as 40-48 X 5 µm. **Ascospores** allantoid, slightly to moderately curved, subolivaceous, 4-5.6(-6.4) X 0.8-1.6 µm.

Occurring on species of **Betula.**

Anamorph: Not seen.

Comments: This fungus is separated from **D. placenta** by its lighter-colored entostromatic tissue, and the host. Infrequently, collections of **D. decorata** contain tan-colored entostromata, resembling those of **D. placenta.** This suggests that the two species might be conspecific, or that **D. placenta** might sometimes occur on **Betula** where it can be mistaken for **D. decorata.** Further studies are needed to clarify this situation.

Petrak (1940) suggested that **Diatrypella discoidea** is a synonym of **D. decorata**, but apparently did not examine type material. Comparison of the types of **D. discoidea** and **D. decorata** leaves little doubt that the two names refer to the same fungus.

Examination of the type of **D. decorata** var. **major** Berl. [PAD] (Berlese, 1900-1905) indicated that it probably is not conspecific with **D. decorata.** The tan entostromatic pseudoparenchyma differed from that regarded herein as typical of **D. decorata;** in addition, that collection was from **Fagus.** Study of additional collections and cultural work are needed to clarify the status of **D. decorata** var. **major.**

Nitschke (1867) listed **Microstoma vulgare** Auersw. as a synonym of **D. decorata**, and listed Fuckel's "Fungi Rhenani" no. 1035 (distributed as **M. vulgare**) as illustrative material. That material is considered lectotypic of **D. decorata** but apparently does not represent **M. vulgare**. **Microstoma vulgare** first was described on a packet label in Rabenhorst's "Fungi Europaei" (no. 253). The name can be traced back to **Sphaeria microstoma** Pers. (Persoon, 1801), which was sanctioned by Fries (1823). The apparent Persoon type [L] appears to be a member of the Diaporthales while a second Persoon collection probably is diatrypaceous but is too decayed to be identified. A Fries specimen of **Sphaeria microstoma**, "Scleromyceti Sueciae" no. 185 [UPS], is a **Cytospora** species. The **Dictionary of the Fungi** (Hawksworth **et al.**, 1983) lists **Microstoma** Auersw. as a synonym of **Valsa**. Thus, all indications are that Fuckel's specimen was misidentified, and that **M. vulgare** cannot considered a synonym of **D. decorata**.

Specimens examined: AUSTRIA: Petrak, F., WSP 31400, IV.1928, M. -Weisskirchen, on **Betula alba**; Petrak, F., WSP 31397, Flora Moravica, VIII.1936, M.-Wesskirchen, on **Betula** sp.; Petrak, F., WSP 31399, IV.1938, M.-Weisskirchen, on **Betula** sp. CANADA: ALBERTA: Newman. J, det. Horner, R., WIS, 8.VII.1955, Kananaskis Forest Experiment Station, on **Betula glandulosa**; NOVA SCOTIA: Prince, A. R., no. 1129 (det. Wehmeyer, L. E., no. 104), MICH, 7.IX.1925, Guysboro Co., Westcooke's Grove, on **Betula** sp. (as "**Diatrypella discoidea** Cke. & Pk"); Wehmeyer, L. E., no. 477, MICH, 10.VII.1931, Colchester Co., Upper Brookside, on **Betula** sp. (as "**Diatrypella discoidea** Cke. & Peck"). ONTARIO: Dearness, J., "Fungi Columbiana" no. 1241, PH, WSP 1887, XI.1897, near Toronto, on **Betula** sp. (as "**Diatrypella discoidea** C. & P."); Horner, R., and Hill, A. W., det. Newman, J., WIS, IX.30.1950, Dorset, on **Betula lutea**; Horner, R. and Hill, A. W., det. Newman, J., no. YB 581, WIS, 2.X.1950, Dorset, on **Betula lutea**; Newman, J., Horner, R., and Hill, A. W., det. Horner, R., and Newman, J., no. YB-216, WIS, 5.X.1950, Clear Lake, Dorset, **Betula lutea**. GERMANY: Nitschke, T., "Fungi Rhenani" no. 1035, B, LECTOTYPE, date and location not given, on **Betula** (originally as "**Microstoma** [as "**Mycrostoma**"] **vulgare** Aw." sp.). ITALY: Anonymous, date and location not given, PAD, on **Betula**; Anonymous, date not given, Monte Germano, PAD, TYPE, on **Fagus** (as **D. decorata** Nits., annotated as "**D. decorata** f. **major**"). USA: COLORADO: Bonar, L, WIS, 9.VI.1923, Manitou, on **Betula fontinalis**; Clements, F. E. and Clements, E. S., "Cryptogamae Formationum

Coloradensium" no. 206, ILL 10559, 25.VI.1906, Minnehaha, on **Betula occidentalis** (as "**Diatrypella favacea** (Fr.) Ces. & De Not."). MAINE: Hansbrough, J. R, det. Dearness, J., MICH, 17.VII.1935, Norway, on **Betula lutea**. NEW YORK: Peck, C. H., "de Thuemen Mycotheca Universalis" no. 864, B, FH, K, NY (FH and K packets marked as "type"), IV.1877, Albany, on **Betula populifolia** (as "**Diatrypella discoidea** Cooke & Peck"); Peck, C. H., NY, "May," year not given, Center, host not given [as "**Diatrype (Diatrypella) discoidea** C. & P."]; Peck, C. H., NYS, TYPE, date not given, Center, on **Betula** sp. (as "**Diatrype discoidea** Cooke & Peck"); Weir, J. R., no. 19356, BPI, "May," year not given, Albany Co., Kasner, on **Betula populifolia** [as "**Diatrypella discoidea** (C. & P.)"]. WYOMING: Wehmeyer, L. E., no. 1080, MICH, 4.VII.1940, Jackson, Camp Davis, on **Betula glandulosa** (as "**Diatrypella discoidea** Cke. & Pk."). USSR: Jaczewski, Komarov, and Tranzschel, "Fungi Rossiae Exsiccati," no. 190, WIS, VI.1896, near Moscow, on **Betula alba**; Tranzschel and Serebrianikow, "Mycotheca Rossica," no. 327, VIII.1911, Berdicino, Prov. Jaroslawl., on **Betula** sp.

ACKNOWLEDGMENTS

Illinois Agricultural Experiment Station Project 68-0331. I thank the curators of the following herbaria for loaning specimens: B, BPI, CUP, DAOM, FH, ILL, K, L, M, MICH, NY, NYS, OSC, PAD, PH, S, UPS, WIS, WSP. I am grateful to Drs. J. L. Crane, Illinois Natural History Survey, R. P. Korf, Cornell University, and D. P. Rogers, Auburn, Washington for helpful comments and suggestions, and Drs. Crane, D. H. Pfister and J. Boise, Harvard University, and J. D. Rogers, Washington State University, for reviewing the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 27-66 January-March 1986

THE "*PLEUROTUS SILVANUS*" COMPLEX

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ABSTRACT

Four species of fungi have been treated under the epithet *Agaricus* (*Pleurotus*) *sylvanus* Saccardo, in *Pleurotus* or *Resupinatus*. The type of *A. sylvanus* is a specimen of *Hohenbuehelia cyphelliformis* (Berk.) Miller, comb. nov. Other fungi mislabelled *sylvanus* are *Resupinatus alboniger* (Pat.) Singer, *Hohenbuehelia pinacearum* Thorn, sp. nov., and *Hohenbuehelia unguicularis* (Fr.) Miller, comb. nov. *Pleurotus atropellitus* Peck is lectotypified herein by a specimen that is *Resupinatus applicatus* (Batsch: Fr.) S.F. Gray. *Agaricus* (*Pleurotus*) *blakei* Berk. & Curt. is a synonym of *Panellus violaceofulvus* (Batsch: Fr.) Sing., and the type specimen represents the third known collection of this species from North America. The new combination *Hohenbuehelia mustaliensis* (Karsten) Thorn, based on *Agaricus mustaliensis* Karsten, is proposed.

INTRODUCTION

Agaricus (*Pleurotus*) *sylvanus* Saccardo was first described on the basis of a collection of fruit bodies on decaying stems of *Clematis*, in Selva, Italy (Saccardo, 1877). Since then, as *Pleurotus silvanus* (Sacc.) Saccardo*

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*Although the original spelling of *sylvanus* (Saccardo, 1877) must be accepted as correct, in accordance with Article 73.1 of the International Code of Botanical Nomenclature (Voss et al., 1983), most authors have followed Saccardo's later decision (1887, p. 379) to change the spelling to *silvanus*. The spelling of choice of cited authors is used thoughout this paper.

(1887) or *Resupinatus silvanus* (Sacc.) Singer (1951), this species has been reported to occur on a wide range of angiosperm and gymnosperm hosts in much of Europe (Pilát, 1935), the United States (Coker, 1944), Ecuador and Argentina (Singer, 1952), Morocco (Malencon & Bertault, 1975), and Tanzania (Pegler, 1977). During a study of species of *Hohenbuehelia* and *Resupinatus* in Ontario (Thorn, 1985), it became apparent that the name *Resupinatus* (or *Pleurotus*) *silvanus* had been applied to three distinct fungi that were recognizable on the basis of morphology and habitat. None of these fungi agreed well with the description of *Agaricus sylvanus* Saccardo (1877). This paper interprets some of the past taxonomic confusion surrounding *A. sylvanus*, and provides the correct names and descriptions for the species to which this name has been misapplied.

Thorn and Barron (1984) reported that *Resupinatus silvanus* and five species of *Hohenbuehelia* were nematophagous and had anamorphs belonging in the genus *Nematoctonus* Drechsler (1941). This report incorporated the prevailing taxonomic confusion of *R. silvanus*. It was subsequently found that the voucher specimen (DAOM #159734) for the culture Thorn and Barron (1984) cited as *R. silvanus* is *Hohenbuehelia unguicularis* (Fr.) Miller. We now believe that all species of *Hohenbuehelia* Schulzer (Schulzer et al., 1866) have *Nematoctonus* anamorphs and are nematophagous, but that species of *Resupinatus* S.F. Gray (1821) do not have *Nematoctonus* anamorphs, and are non-nematophagous. *Hohenbuehelia* has traditionally been separated from *Resupinatus* by the presence of hymenial metuloids, which are absent in *Resupinatus* (Singer, 1951). This distinction still holds true, but several species of *Hohenbuehelia* have previously been classified in *Resupinatus* because their hymenial metuloids are particularly inconspicuous. The metuloids of *Hohenbuehelia* are metachromatic in a 0.05 % (w/v) aqueous solution of Brilliant Cresyl Blue (Donoso, 1981), and turn bright magenta in contrast to other hymenial elements that turn pale blue. Cresyl blue thus renders the inconspicuous metuloids of certain species of *Hohenbuehelia* clearly visible. The metuloids of these species are described and illustrated herein for the first time.

A HISTORY OF MISAPPLICATIONS

Saccardo (1877) described the fruit bodies of *Agaricus sylvanus* as cupulate, 5-8 mm broad, grey to black, with

distant, dirty-white gills and strongly curved, cylindric spores. This description, and the occurrence of Saccardco's fungus on *Clematis*, is strongly reminiscent of *Agaricus cyphelliformis* Berkeley (1837), described from stems of *Penstemon*. Examination of the type specimen of *Agaricus sylvanus* confirmed this suspicion.

Three other species misidentified as *Pleurotus* (or *Resupinatus*) *sylvanus* are, at first glance, very similar to each other. Their fruit bodies are cupulate to flabelliform, grey to black, gelatinized, and generally less than 1 cm broad. They have grey, brown or black gills, and hyaline, inamyloid spores that are elliptical in face view and slightly concave on the adaxial face in profile view (phaseoliform). Two species form jet black or blue-black basidiomes that are nearly glabrous in age, with at most fine, white floccose tufts or wisps scattered over the surface of the cap. One of these species occurs on conifers and usually forms a conspicuous lateral pseudostipe. The other occurs on woody dicots and is sessile and dorsally attached. The third species forms flabelliform or cupulate basidiomes with a lateral pseudostipe, that are densely villose with coarse buff-coloured or greyish hairs over the disk and pseudostipe. It occurs on hardwood twigs or logs.

The species found on conifers is *Pleurotus silvanus* sensu Josserand (1933). Josserand reported that two different fungi had been treated by various authors under the name *Pleurotus applicatus* (Batsch: Fr.) Quélet: one with approximately spherical spores, and the other with elliptical spores. Josserand identified the spherical-spored species as the true *P. applicatus*, following the tradition of Massee (1902), Bresadola (1928), Lange (1930), Pilát (1930) and others. Josserand believed that the elliptical-spored species that Quélet (1888) and Rea (1922) had described under *P. applicatus* was the same species that had been collected in the Lyon area of France on *Abies* and *Picea*. Josserand called this species *P. silvanus* with some hesitation, noting the differences in habitat and spore curvature, but he could find no other species of *Pleurotus* in the literature with a description that matched his collections any better. Krieglsteiner (1979) has provided a more recent and detailed account of the occurrence in Germany of *P. silvanus* sensu Josserand (as *Resupinatus silvanus*). A collection cited by Josserand (1933) as *P. silvanus* was examined and found to be conspecific with collections seen from North America. These collections

represent a species of Hohenbuehelia, but their hymenial metuloids are particularly inconspicuous and are clearly visible only in cresyl blue.

The mycological literature was searched for a valid name applicable to *P. silvanus* sensu Josserand. Since the coniferous habitat was considered of primary importance, the list of possibilities was rapidly narrowed to *Agaricus* (*Pleurotus*) *blakei* Berkeley & Curtis (1859), collected on *Abies* in Maine, U.S.A.; *Agaricus mustaliensis* Karsten (1876), on *Pinus* in Finland; and *Pleurotus atropellitus* Peck (1886), on both hardwoods and conifers in eastern U.S.A. None of the type specimens (see below) was conspecific with *Pleurotus silvanus* sensu Josserand. *Agaricus blakei* Berk. & Curt. is a synonym of *Panellus violaceofulvus* (Batsch: Fr.) Singer; *Agaricus mustaliensis* is *Hohenbuehelia mustaliensis* (Karsten) Thorn; and *Pleurotus atropellitus* Peck is a synonym of *Resupinatus applicatus* (Batsch: Fr.) S.F. Gray. Therefore, *Hohenbuehelia pinacearum* Thorn is proposed for *P. silvanus* sensu Josserand.

Pleurotus silvanus sensu Coker (1944) is the species with nearly glabrous, jet black, sessile basidiomes growing on hardwoods. Pilát (1935) originally identified this fungus as *P. silvanus*, but the specimens cited under *P. silvanus* in his monograph of *Pleurotus* included both this species ("Blake 1859, as *P. niger*, Maine, U.S.A., in herb. Burt") plus *H. pinacearum*, and the type of *P. silvanus*, which is *H. cyphelliformis*. Coker (1944) believed that he had the same concept of *P. silvanus* as Pilát (1935), because he had studied the Maine specimen cited by Pilát. *Pleurotus silvanus* sensu Coker is macroscopically almost indistinguishable from *H. pinacearum*, except by habitat. Coker reported what is clearly *H. pinacearum* under *P. unguicularis*, saying that, "before we had found a name for our plant we had thought to call it a variety of *silvanus*." Coker was probably misled by Pilát's citation of collections of *P. unguicularis* from *Abies*.

Miller (in Miller and Manning, 1976; and Miller, in press) has maintained Coker's concepts of *P. silvanus* and *P. unguicularis*, and provided an additional important detail about *P. silvanus* sensu Coker: the cuticular hyphae are brown-walled and have "staghorn branches". This species has a rameales structure in the cap cuticle, has diverticulate cheilocystidia, lacks metuloids, and the habitat differs from that of *H. pinacearum*. In addition, a culture of *H. pinacearum* (R.G. Thorn #831015/04) produced conidia and

adhesive nematode-trapping devices typical of the genus *Nematoctonus* Drechsler (1941, 1946). A culture of *P. silvanus* sensu Coker, received from Miller (VT #1364), produced no conidia and was not nematophagous under test conditions described by Thorn and Barron (1984). *Pleurotus silvanus* sensu Coker is clearly not a *Hohenbuehelia*, but is a species of *Resupinatus*.

Singer (1952) also studied "Blake 1859", cited by Pilát (1935) and Coker (1944) as *P. silvanus* and based his report of the occurrence of *R. silvanus* in Ecuador and Argentina on that species concept, listing "*P. alboater* Patouillard" [sic] as a synonym. Singer (1978) later decided that the South American material was different from *R. silvanus*, and proposed the new combination *Resupinatus alboniger* (Pat.) Singer (based on *P. alboniger* Patouillard, 1893, from Ecuador). The description of *R. alboniger* (Pat.) Singer (1978) matches *P. silvanus* sensu Coker very well. The type specimen of *P. alboniger* Pat. (Quito, 1 fevrier 1892, leg. Lagerheim, FH !) differs in some minor details from the few North American collections seen, but these are not considered worthy of specific distinction. The correct name for *Pleurotus silvanus* sensu Coker is therefore *Resupinatus alboniger* (Pat.) Singer.

The third species that has been identified as *P. silvanus* is *Pleurotus unguicularis* (Fr.) Quélet, as described by Lange (1937) but not Coker (1944) or Miller (in press). The fruit-bodies of *P. unguicularis* are brownish or black, sometimes with a silver frosting, are villose or tomentose over the disk and pseudostipe, and have grey to brown to black lamellae with white margins. Macroscopically, *P. unguicularis* is very similar to *Resupinatus applicatus* (Batsch: Fr.) S.F. Gray, in the restricted sense of Coker (1944). Microscopically, it is readily distinguished from *R. applicatus* by its elliptical spores and inconspicuous metuloids with brown-walled bases and crystal-encrusted apices. The bases of the basidia and basidioles of *P. unguicularis* are also brown, but not as dark as the bases of the metuloids. Because of its metuloids, and *Nematoctonus* anamorph (Thorn and Barron, 1984, as *R. silvanus*), *P. unguicularis* is clearly a species of *Hohenbuehelia*.

The following key should facilitate identification of species in this group. The character "Q" represents spore length divided by width. Spore lengths do not include the hylar appendage.

KEY TO THE SMALL, DARK, GILLED MEMBERS OF *HOHENBUEHELIA* AND *RESUPINATUS* OF CANADA

1. Spores ovate, elliptic, cylindric or allantoid ($Q \geq 1.7$; Qavg usually ≥ 2.0) 2
1. Spores globose or subglobose ($Q \leq 1.3$, Qavg near 1.1).. 9
   2. Lamellae remaining pale in age: white, greyish-white or yellowish 3
   2. Lamellae dark, or becoming dark by maturity 4
3. Spores cylindric, slightly to disctinctly curved, 8-10 (11.5) X 3.0-3.8 (4.2) µm; pileus grey to brown, black when dry, with fine white wisps or scales .... *Hohenbuehelia cyphelliformis*
3. Spores elliptic-phaseoliform, 6.5-9.0 X 3.2-4.5 µm; pileus pale to dark brown or blue-black, villose or tomentose ..... *Hohenbuehelia atrocaerulea* (Fr.) Singer*
   4. Metuloids present in hymenium, often inconspicuous except in cresyl blue mounts 5
   4. Metuloids absent from hymenium; cheilocystidia fusoid-ventricose to diverticulate; epicutis a rameales structure; on woody dicots .... *Resupinatus alboniger***
5. Pileus nearly glabrous, with at most fine white wisps or scales, jet black or blue-black 6
5. Pileus prominently tomentose or villose; grey, brown, or black 7
   6. Metuloids prominently projecting, visible under 10X on lamellar faces; on hardwoods .... *Hohenbuehelia nigra* (Schw.) Singer*
   6. Metuloids not projecting prominently; lamellar faces at most atomate under 10X due to crystal-encrusted metuloid apices; on conifers .... *Hohenbuehelia pinacearum*
7. On conifers; pileus black, with dense pallid or dark tomentum; metuloids projecting prominently .... *Hohenbuehelia mustaliensis***
7. On hardwoods 8
   8. Metuloids projecting prominently; spores 9-13.5 X 4.5-6 µm; pileus warm brown, usually with darker tomentum ..... *Hohenbuehelia reniformis* (Mey.: Fr.) Sing. sensu Fr.*
   8. Metuloids not projecting prominently, with clavate, hyaline apices; spores 6-8.5 X 3-4 µm; pileus dark, often with silvery crust, and with buffy tomentum ..... *Hohenbuehelia unguicularis*

9. Pileus conspicuously villose or tomentose over disk and pseudostipe, cupulate to flabelliform, 5-20 mm broad; on hardwoods 10
9. Pileus glabrous to pruinose (with at most a fringe of white "tomentum" at point of attachment from basal mycelium), cupulate and dorsally attached; on hardwoods and conifers .... ***Resupinatus striatulus*** (Pers.: Fr.) Murr.*
   10. Pileus tomentum buffy or grey .... ***Resupinatus applicatus*** (Batsch: Fr.) S.F. Gray*
   10. Pileus tomentum dark brown or black, often forming a distinct mat over disk .... ***Resupinatus trichotis*** (Pers.) Sing.*

*Not treated **Not known from Canada

SPECIES DESCRIPTIONS

Hohenbuehelia cyphelliformis (Berk.) Miller, comb. nov.[1]
Figures 1 A-B, 2 A-H, 10 A-C.
Basionym: ***Agaricus cyphelliformis*** Berkeley (1837: 511)
= ***Pleurotus cyphelliformis*** (Berk.) Saccardo (1887: 379)
= ***Resupinatus cyphelliformis*** (Berk.) Singer (1951: 253)
= ***Geopetalum cyphelliforme*** (Berk.) Kuehner & Romagnesi, nom. invalid. (1953: 68)
= ***Marasmius spodoleucus*** Berkeley & Broome (1859: 358), fide Singer (1975)
= ***Pleurotopsis spodoleucus*** (Berk. & Br.) Earle (1909: 412)
= ***Agaricus (Pleurotus) sylvanus*** Saccardo (1877: 1)
= ***Pleurotus sylvanus*** (Sacc.) Saccardo (1887: 379; as ***silvanus***)
= ***Acanthocystis sylvana*** (Sacc.) Konrad & Maublanc (1937: 309 II; as ***silvanus***)
= ***Resupinatus sylvanus*** (Sacc.) Singer (1951: 253; as ***silvanus***)
= ***Geopetalum sylvanum*** (Sacc.) Kuehner & Romagnesi, nom. invalid. (1953: 68; as ***silvanum***)

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[1]This and other new combinations by Miller are also proposed in the proceedings of the 1984 Tricholomataceae symposium (Miller, in press), the publication of which has been delayed. These combinations are duplicated herein, to ensure the priority and valid publication of Miller's combinations.

= ***Marasmius broomei*** Berkeley (in Berkeley and Broome, 1879: 209), fide Singer (1975)

= ***Pleurotus campanulatus*** Peck (1891: 131), fide Smith (1934)

= ***Resupinatus campanulatus*** (Peck) Murrill (in Murrill et al., 1915: 241)

= ***Urceolus sambucinus*** Velenovský (1939: 44), cf. Horak (1968)

SELECTED DESCRIPTIONS AND ILLUSTRATIONS: North America: Peck (1891: 131, pl. 2 fig s. 13-15; as ***P. campanulatus***), Smith (1934: 482, pl. 10, fig. 2). Europe: Berkeley (1837: 511, Tab. 15, fig. 3), Saccardo (1877: 1-2; as ***A. sylvanus***) Pilát (1935: 71, Tab. 21, figs. 2, 3, 6).

DESCRIPTION OF CANADIAN COLLECTIONS: Fruit Bodies cupulate, pendent or conchate, 2-6 mm diam., dorsally or laterally attached, greyish brown to almost black (6D-F3; Kornerup and Wanscher, 1978), appearing glabrous and translucent-striate when fresh and moist (lines one unit darker), drying black, opaque, with fine white floccose bits or wisps over surface. Margin even or slightly wavy. Gills radiating from a near central point on underside, stark white, becomimg faintly greyish, narrow to moderately thick, distant, occasionally becoming slightly tortuous-anastomosing, smooth or finely frosted under 10X. Cuticle 15-20 µm deep, black or dark brown in KOH, a repent tangle of heavily spiral-encrusted brown hyphae, (1.5) 2-5 (6) µm diam., with a few fine, loose ends 1.5-2.0 µm diam. terminating in small hourglass-shaped cells 3-4.5 X 1.5-1.7 µm, surrounded by a mucoid ball 3-4 (6) µm diam. All hyphae with single clamps. Gelatinous Zone hyaline, 220-300 µm deep, hyphae in a loose tangle, 1-4 (5) µm diam., most smooth, but a few near cuticle finely spiral-encrusted. Trama 30-50 µm deep, densely tangled, clay brown (in KOH), becoming paler toward the gill trama; hyphae mostly parallel, radially arranged, (1) 3-7 µm diam.,

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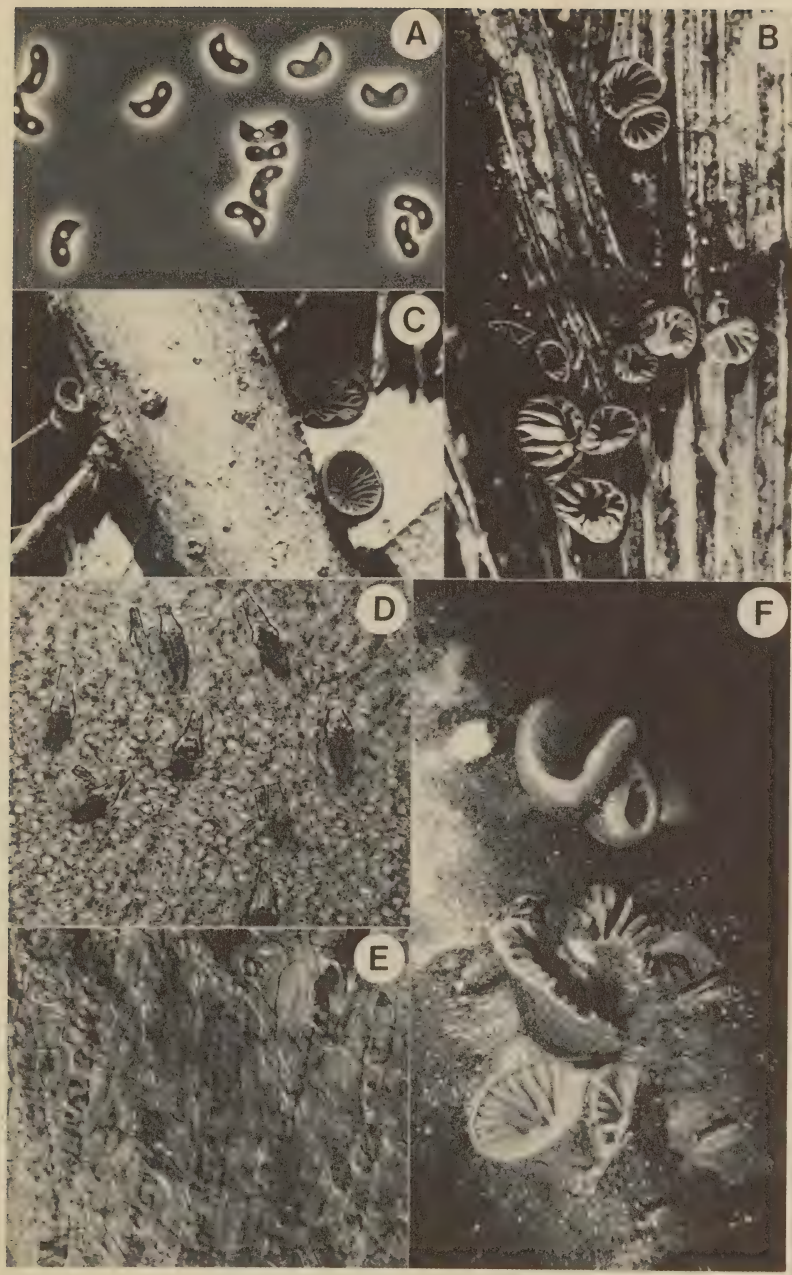
Figure 1 A-B: ***Hohenbuehelia cyphelliformis***. A) Basidiospores of RGT # 841117/02, X 750; B) basidiomes of RGT #841013/01, X 1.8. C-E: ***Hohenbuehelia pinacearum***. C) Basidiomes of RGT #831015/04, X 1.8; D) metuloids of Peck s.n., Bennetts, N.Y., 1884 (NYS), stained in cresyl blue, X 300; E) cuticle of Peck s.n., Bennetts, N.Y., 1884, showing smooth and coarsely spiral-encrusted hyphae, X 500. F: ***Hohenbuehelia unguicularis***, basidiomes of DAOM #191960, X5 (photograph courtesy of J. Ginns, DAOM).


A
B
C
D
E
F

smooth or finely encrusted, thin-walled. Gill Trama quite interwoven, pale beige (KOH) above, becoming hyaline near gill margins. Subhymenium indistinct, blending in colour from trama to hymenium, medium brown (interstices) to subhyaline (gill edges), 5-10 µm deep, hyphae 1.5-3.0 µm diam. Hymenium 25-37 µm deep, hyaline at gill edges, with hyaline apices and brown bases in interstices. Basidia 4-spored, clavate, (21) 26-30 X 6.2-8 µm. Cheilocystidia fusoid-capitate, with well-formed or poorly formed hour-glass, occasionally branched, 18-38 X 4-7 µm, hour-glass 4-6.5 X 1.2-2.0 (2.5) µm, mucoid ball 5-8 µm diam. Metuloids clavate or fusoid, thin-walled (up to 0.5 µm thick), not projecting (resembling basidioles), bases pale brown, 21-40 X 4.5-7.0 µm, brilliant magenta in Cresyl Blue, apices entirely obscured by conical or ovoid crystalline masses that are 8-12 (16) µm diam. X 12-20 µm tall. Spores white in print, hyaline, inamyloid, smooth, broadly allantoid, (7.5) 8-10 (11.5) X 2.8-3.8 (4.2) µm.
HABITAT: On dead twigs, or stems of woody biennial or perennial dicots in rich, moist environments. Ontario specimens were found on *Arctium* and *Heracleum* in moist "old fields". Host plants reported in the literature include *Anethum*, *Angelica*, *Arctium* (Pilat, 1935), *Clematis* (Saccardo, 1877), *Morus* (Peck, 1891), *Penstemon* (Berkeley, 1837), *Sambucus* (Pilat, 1935; Velenovský, 1939), *Solanum* (Smith, 1934), *Thapsia* (Malencon and Bertault, 1975) and *Ulmus* (Berkeley and Broome, 1859).
DISTRIBUTION: Reported from Czechoslovakia, England, Hungary, Italy and Yugoslavia in Europe, Morocco in North Africa, Michigan and New York in the United States, and now found in Ontario, Canada.
SPECIMENS EXAMINED: Canada: Ontario: Dennison Farm, Opeongo Lake, Algonquin Park, R.G. Thorn #841013/01, on *Arctium minus* & #841013/11, on *Heracleum maximum*; Conc. #3 Eramosa

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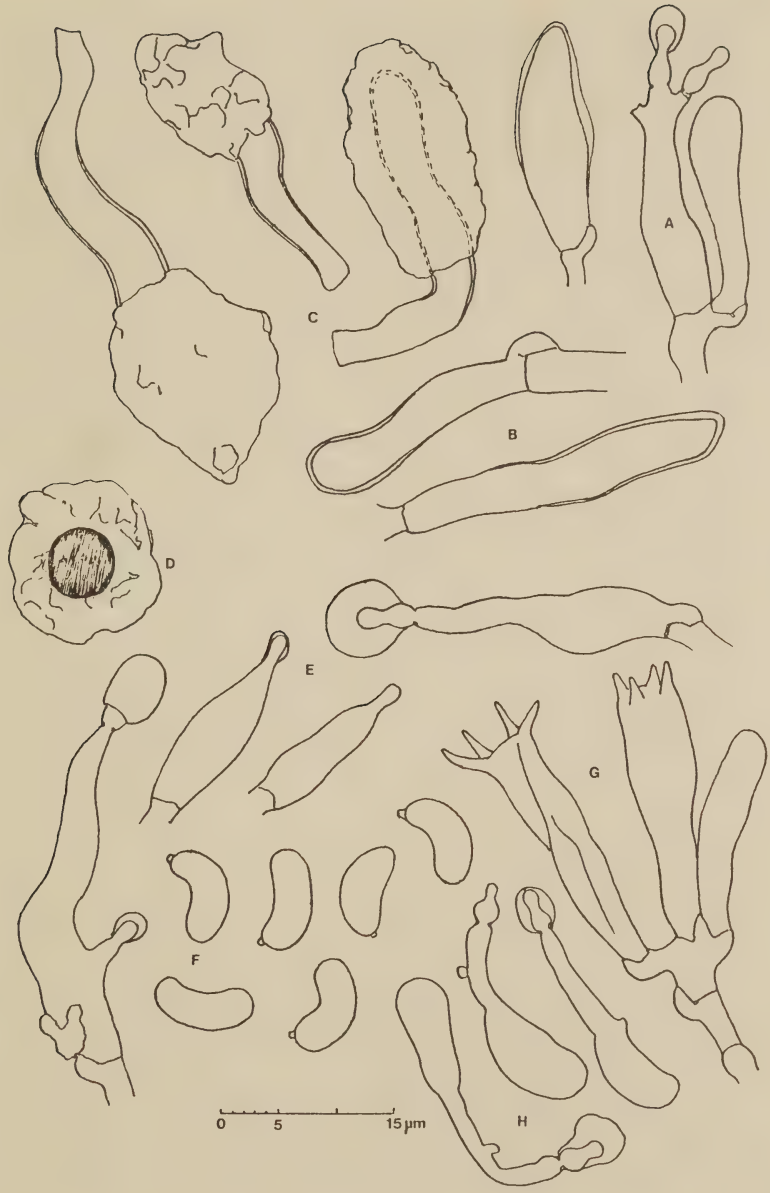
Figure 2 A-H: *Hohenbuehelia cyphelliformis*. A-C: RGT #841117/02. A) A cheilocystidium and basidioles; B) three metuloids with crystalline caps dissolved away; C) three metuloids with crystal-encrusted apices. D-H RGT #841013/01. D) Looking down on a metuloid stained in cresyl blue; E) four cheilocystidia; F) allantoid basidiospores; G) basidia and basidiole; H)basidiospores germinating on water agar in the presence of nematodes to form adhesive knobs at the end of a germ tube.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15 µm

Twp., Wellington Co., on *Arctium*, R.G. Thorn #841117/02. Italy: Selva, Treviso, on *Clematis vitalba*, Mar. 1877, P.A. Saccardo, PAD #3644 (type of *Agaricus sylvanus* Saccardo). OBSERVATIONS: *Hohenbuehelia cyphelliformis* is readily recognised by the combination of its size, cupulate habit, stark white, distant gills, and its habitat. Although the specimens found during this study appear to be the first for Canada, it might prove to be quite common if a diligent search was made in its habitat, which is easily passed by.

The metuloids of this species are particularly inconspicuous, but in mature specimens their conical crystalline caps are readily visible in mounts of whole gills. Cresyl blue renders the metuloids brilliant magenta in contrast to the basidia and basidioles which they morphologically resemble. The metuloids of *H. cyphelliformis* (Figs. 2 B, C) do not appear to be deep-seated as are those of most other species of *Hohenbuehelia*, but seem to originate in the subhymenium. They are also thin-walled, and clavate or occasionally lanceolate, and thus stretch the term metuloid, which is usually taken to mean thick-walled, lanceolate, crystal encrusted cystidia. These cystidia in *H. cyphelliformis* are analogous, if not identical in appearance, to the metuloids of other *Hohenbuehelia* species, and so are labelled metuloids.

The type specimen of *Agaricus sylvanus* is typical of this species, especially the distant white gills, strongly curved spores, and habitat mentioned in the original description (Saccardo, 1877). Examination of the type specimen showed that these and other microscopic features were typical (see "Notes on Type Specimens", later).

Hohenbuehelia pinacearum Thorn, sp. nov.

Figures 1 C-E, 3 A-G, 4 A-E.

Pileus 4-10 mm latus, lentus, gelatinosus, cupulatus aut flabelliformis, sessilis aut pseudostipite brevi laterali cernuo, niger vel ex caeruleo niger, pilis vel squamis albis tenuibus sparsis vestitus. Lamellae subdistantes, crassiusculae, primo argenteae demum ex caeruleo nigrae. Sporae albae, hyalinae, haud amyloideae, anguste phaseoliformi-ellipticae, laeves, (6.0) 6.2-8.5 (9.0) X (2.5) 3.0-3.8 (4.2) µm (ad 10.5 X 5.5 µm basidiis bisporis). Basidia tetrasporis (forma rarior basidiis bisporis), clavata, hyalina, (22) 25-32 X 6.0-7.5 µm. Cheilocystidia fusiformia vel flexuoso-cylindracea, hyalina, 22-45 X 4-8 µm, capitata aut non capitata, interdum ramosa, duobus

capitulis praedita; cellulae secretoriae apicales 5-8 X 2-3 µm, mediis constrictae. Metuloidis hymenii inconspicuae, hyalinae, fusiformes vel lanceolatae, 37-50 X 6-11 µm; pariete praeter apices tenuiter tunicatos 1-2 µm crasso, in solutione azureae cresylii metachromaticae, purpureoroseae; apices crystallinis hyalinis incrustati. Pilocystidia hyalina, cylindracea, ad 50 µm longa X 3-7 µm diam., tenuiter tunicata; cellulae apicales longae, mediis constricae (interdum constrictionibus duabus praeditae), 12-25 X 5-7 µm. Hyphae fibulatae. Ad truncos et ramos corticatos coniferos. Holotypus leg. R.F. Cain, Lake Temagami, Ontario, Canada, July 18, 1938, TRTC #13200; isotypus DAOM #50083 & #80600.

SELECTED DESCRIPTIONS AND ILLUSTRATIONS: North America: Coker (1944: 78-9, pl. 42 lower, pl. 49 figs. 6-8; as *Pleurotus unguicularis*), Miller and Manning (1976: 320-321, Figs. 2 n-p, 5; as *P. unguicularis*). Europe: Josserand (1933: 360-364, Figs. 9 B-C; as *P. silvanus*), Pilát (1935: Tab. 20, figs. 3, 5, 7; as *P. silvanus* - the description much confused), Konrad and Maublanc (1937: 309 II; as *Acanthocystis silvanus*), Krieglsteiner (1979: 43; as *Resupinatus silvanus*).

DESCRIPTION: Fruit Bodies cupulate to conchate or flabelliform, sessile or pendent from a short pseudostipe, 4-10 mm diam., surface moist and mostly glabrous when fresh, black or blue-black (20F4), with a few scattered white wisps, particularly toward the margin; margin incurved, even or becoming wavy, not striate. Gills radiating from point of attachment or a central or excentric point on underside, at first silver-grey (B1), becoming deep olive brown (4-5F4) to black or blue-black (20F4); moderately narrow, subdistant. Cuticle dark brown (KOH), 10-25 µm thick, of densely woven repent hyphae, 2.5-7 (9) µm diam., many with broad spiral bands of encrusting pigmented material; with hyaline tomentum hyphae up to 50 µm tall X 3-7 µm diam., tipped with long hour-glass cells (sometimes with 2 constrictions), 12-25 X 5-7 µm. Gelatinous Zone black in mass, hyaline in section, 250-500 µm thick, of loosely tangled hyphae with strongly gelatinised outer walls and refractive lumens, 2-3 (5) µm diam. Trama composed of a pale brown (KOH), compact zone about 50 µm deep, of hyphae 2-3 µm diam., the subhyaline, less dense lower zone extending into gills, hyphae tangled, 3-5 µm diam. Gill Trama hyaline, of nearly parallel hyphae 3-8 (12) µm diam., with gelatinised wall up to 3.5 µm thick. Subhymenium pale brown (KOH), thin.

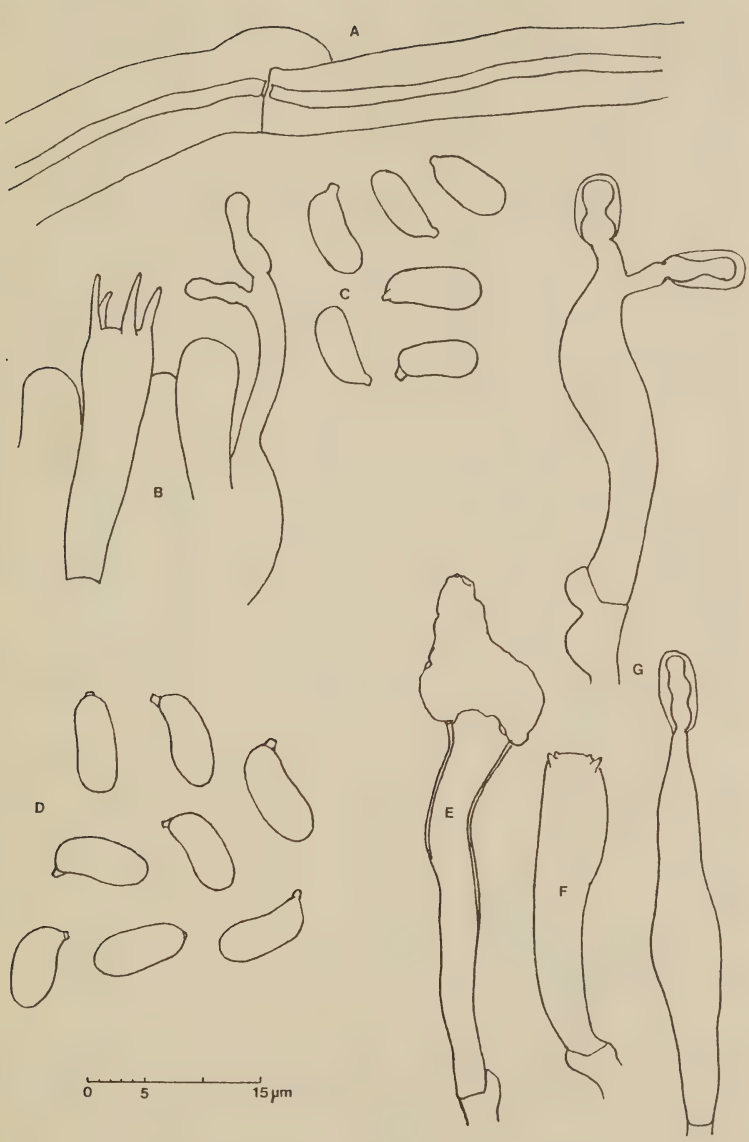
Hymenium hyaline, about 30 µm deep. Basidia (2-) 4-spored, clavate, hyaline, (22) 25-32 X 6-7.5 µm. Cheilocystidia fusoid or flexuous-cylindric, capitate or not, 22-45 X 4-8 µm, with 1 or 2 hour-glass secretory cells 5-8 X 2-3 µm. Metuloids deep-seated, flexuous, hyaline cells 37-50 X 6-11 µm, with walls up to 2.0 µm thick, except at the apex where they are thin-walled and collapsing, metachromatic in cresyl blue, capped in age with a cone of hyaline, crystalline encrusting material 15-20 (30) µm tall X 8-15 µm diam. Spores white in print, hyaline, inamyloid, smooth, narrowly elliptic-phaseoliform, (6.0) 6.2-8.5 (9.0) X (2.5) 3.0-3.8 (4.2) µm from 4-spored collections and 7.5-10.5 (11.0) X 4.4-5.5 (5.7) from 2-spored Peck collection (Bennetts, N.Y., in NYS)

HABITAT: On bark of conifers; on dead, standing trunks, fallen logs and branches, and dead branches on live trees.

DISTRIBUTION: Pilat (1935) listed collections on conifers from Belgium, Czechoslovakia and France. Josserand (1933) and Pilat believed that *P. applicatus* sensu Rea (1922), from England, was this species. The report by Krieglsteiner (1979) of *Resupinatus silvanus* in W. Germany represents this species. In North America, it is known from North Carolina (Coker, 1944, as *P. unguicularis*) and New York in the United States, and from Ontario, Quebec and New Brunswick in Canada. Other published reports of *Pleurotus* or *Resupinatus silvanus* that have been seen refer to *Resupinatus alboniger* or *Hohenbuehelia cyphelliformis*.

SPECIMENS EXAMINED: Canada: New Brunswick: Kouchibouguac National Park, on *Abies* (not *Betula* as stated on label), May 16, 1977, R. Milliken, DAOM #165824. Ontario: Maple, on *Tsuga canadensis*, May 5, 1936, J.W. Groves, TRTC #9470; Lake Temagami, on *Abies balsamea*, July 18, 1938, R.F. Cain, TRTC #13200, holotype (isotypes as DAOM #50083 and 80600); Petawawa, on *Pinus strobus*, Sept. 6, 1943, J.W. & E. Groves, DAOM #11428; Petawawa, on *Abies*, Sept. 20, 1945, J.W. Groves, DAOM #16436; Wolf Howl Pond, Algonquin Provincial Park, on *A. balsamea*, Oct. 15, 1983, R.G. Thorn #831015/04. Quebec: Percé, on *A. balsamea*, Aug. 14, 1959, W.B. & V.G.

Figure 3 A-G: *Hohenbuehelia pinacearum*. A-C: DAOM #11428. A) Hypha from gill trama with thickened, gelatinised walls; b) a basidium, basidioles, and cheilocystidium. D) DAOM #84313, basidiospores. E-G: TRTC #13200. E) A metuloid; F) a basidium; G) two cheilocystidia.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Cooke, DAOM #84313. United States: New York: Bennetts, on *Picea*, n.d. (1884 fide J.H. Haines, pers. comm.), C.H. Peck, NYS. France: Rhône: Chansaye, on *Picea abies* or *Abies pectinata*, Jan. 3, 1933, M. Josserand XII/10, in herb. Josserand.

OBSERVATIONS: This species may be macroscopically indistinguishable from *H. nigra* except by habitat, unless the projecting metuloids of the latter species can be seen under a magnifying lens. *Hohenbuehelia pinacearum* is characterised by its jet black, nearly glabrous pileus that is cupulate to conchate in form, its dark gills, very inconspicuous, hyaline metuloids, and occurrence on conifers. *Resupinatus alboniger* is also macroscopically very similar, but can be distinguished by its very different cheilocystidia, cap cuticle and habitat. The cheilocystidia of *H. pinacearum*, like those of many species of *Hohenbuehelia*, have a well-defined hour-glass-shaped secretory cell at their apex. These hour-glass cells, however, are easily crushed and lost in squash mounts of either gill sections or fragments. The cheilocystidia of *R. alboniger*, on the other hand, lack apical hour-glass secretory cells and range from simply fusoid-ventricose to quite diverticulate. These diverticulate cheilocystidia and the diverticulate cuticular hyphae that form a rameales structure in the cap cuticle, are characteristic of *Resupinatus*. The cuticular hyphae of *H. pinacearum* are not diverticulate or markedly branched, but have fine to coarse spiral bands of encrusting pigment (Fig. 1 E).

Josserand (1933) used the name *silvanus* for this fungus with some hesitation, but said that he could not find any other described *Pleurotus* that matched his. He noted a disagreement with Saccardo's *P. silvanus* regarding the habitat and spores. In addition, the gills of Saccardo's *P. silvanus* were described as "*latis, remotiusculis, sordide albis*". The type specimen of *Agaricus sylvanus* is *Hohenbuehelia cyphelliformis*.

No suitable name was found for this species. The description of *Agaricus mustaliensis* Karsten (1876) was

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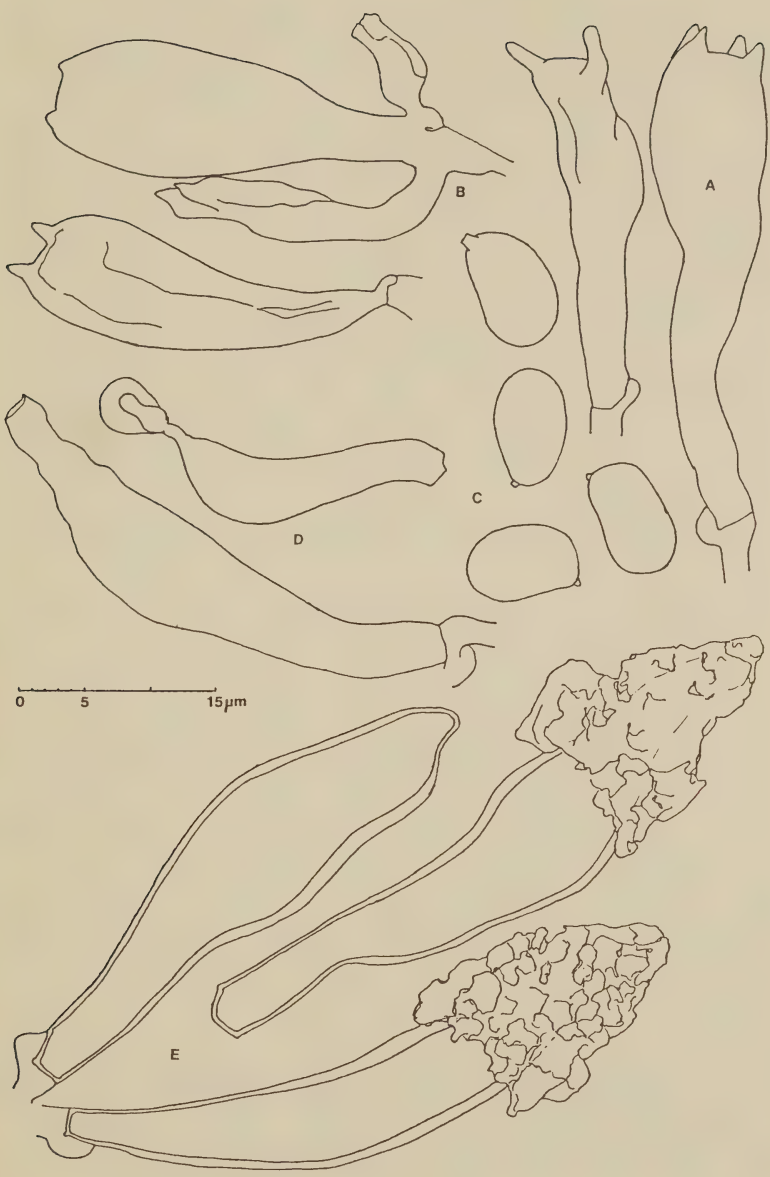
Figure 4 A-E: *Hohenbuehelia pinacearum*, Peck s.n. Bennetts, N.Y. 1884 (NYS), as *Pleurotus atropellitus*. A) A four-spored basidium; B) four two-spored basidia, one collapsed and two collapsing; C) basidiospores; D) two cheilocystidia; E) three metuloids, one with crystalline cap dissolved away.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suggestive of this species, but the type specimen (Fungi fenniae #605, FH) proved to have a tomentose cap, and prominent metuloids. *Agaricus mustaliensis* is therefore a *Hohenbuehelia* most closely allied to *H. nigra*. *Agaricus blakei* Berkeley and Curtis (1859) was collected on *Abies*, but was described as rufous, and thus seemed an unlikely name for this species. Its type specimen (Curtis #6289, FH, K) represents the third known North American collection of *Panellus violaceofulvus* (Batsch: Fr.) Singer. Although the description of *Pleurotus atropellitus* Peck (1886) mentions a villose cap, which is not characteristic of *H. pinacearum*, Peck listed the habitat as deciduous and coniferous wood, and the spores as 7.5–9 X 4–5 µm, suggesting that his species concept might include *P. silvanus* sensu Josserand. Specimens of "*P. atropellitus*" on conifers are invariably this species. The specimen that Coker (1944) mentioned as type of *P. atropellitus* (Fort Edward, New York, E.C. Howe, NYS) is herein designated lectotype. This specimen was collected on deciduous wood, and represents *Resupinatus applicatus* (Batsch: Fr.) S.F. Gray.

Hohenbuehelia pinacearum is probably widely distributed in moist coniferous forests of the northern hemisphere.

Hohenbuehelia unguicularis (Fr.) Miller, comb. nov.
Figures 1 F, 5 A–I, 8 A–C, and E.
Basionym: *Agaricus unguicularis* Fries (1828: 24)
= *Pleurotus unguicularis* (Fr.) Quélet (1872: 113)
= *Phyllotus unguicularis* (Fr.) Karsten (1879: 93)
= *Calathinus unguicularis* (Fr.) Quélet (1886: 47)
= *Resupinatus unguicularis* (Fr.) Singer (1951: 253)
= *Geopetalum unguiculare* (Fr.) Kuehner and Romagnesi, nom. invalid. (1953: 68)
= *Pleurotus atrocaeruleus* (Fr.) Gillet var. *minimus* Dearness & Bisby, in Bisby et al. (1929: 104)
SELECTED DESCRIPTIONS AND ILLUSTRATIONS: North America: none. Europe: Pilát (1935: Tab. 22, figs. 2, 3 – the description badly confused); Lange (1937: 73, pl. 66, fig. C); Konrad and Maublanc (1937: 309 II, as *Acanthocystis Leightonii* – very good).
DESCRIPTION OF NORTH AMERICAN MATERIAL: Fruit Bodies cupulate or conchate, pendent from an excentric dorsal or lateral pseudostipe, up to 6 mm diam.; when dry, silver grey (B1) to brownish-black (6E3+) or black, glabrous only where weathered, otherwise white pruinose to finely tomentose, becoming densely strigose over pseudostipe with white to

buffy (4A2) hairs; when revived margin becomes medium warm brown or slightly olive brown (5-6E3-4), faintly striate in some. Gills radiating from a point on underside, moderately narrow, subdistant, pinkish grey when fresh (notes with DAOM #191960), grey-brown to black when dry, finely frosted under 10X, margin entire. Cuticle pale to dark brown (KOH), densely tangled, 10-25 µm deep, of pigment-encrusted hyphae with clamps, 2-6 µm diam. Epicutis of hyaline or golden brown, smooth, wavy hyphae up to 200 µm tall X 2-5 µm diam., occasionally inflated to 12 µm, with scattered hour-glass cells 7-9 X 2.5-3.0 µm. Gelatinous Zone often the majority of the trama, subhyaline, with pale brown and hyaline hyphae tangled and ascendant below, 1.5-3.5 µm diam., smooth; becoming repent, deeper brown and finely encrusted toward the cuticle, 2-6 µm diam. Trama pale brown (KOH), 100-530 µm deep, darkest at upper edge adjacent to gelatinous zone, where hyphae are parallel or nearly so; tangled below and descending into gills, hyphae 3-6 µm diam., with thin, or thickened, gelatinised walls. Gill Trama pale brown, parallel-interwoven, of hyphae 3-5 µm diam. Subhymenium subhyaline and barely distinct to dark brown, 10-15 (40) µm deep. Hymenium medium to dark brown (KOH), with dark flecks of metuloid bases, 24-35 µm deep. Basidia 4-pronged, clavate, with dark brown sap that does not always extend to apices, leaving them hyaline, (22) 25-32 X 5.5-7.5 µm. Cheilocystidia clavate or fusoid-ventricose, 22-37 (60) X 4-8 µm, with 1 or 2 hour-glass cells 5-9 X 2.5-4 µm, mucoid balls 4-6 µm diam., sometimes coalescing over gill edge, or occasionally with 1 or 2 cylindric projections at tip up to 40 m long X 1.0-1.5 µm. Metuloids clavate or fusoid with rounded, often collapsing apices, dark brown and with walls thickened to 1.5 µm from base to middle, thin-walled and hyaline at apex; scarcely projecting, but with conical cap of hyaline or yellowish crystalline material 8-12 µm diam. (looking down on hymenium), 20-77 (90) X 6-12 (15) µm. Walls deep purple in cresyl blue. Spores white in print, hyaline, inamyloid, smooth, narrowly elliptic-phaseoliform, (5.0) 6.0-8.5 (9.0) X (2.8) 3.0-4.0 (4.5) µm.

HABITAT: On dead trunks and branches of hardwoods, with or without bark.

DISTRIBUTION: Described from Sweden (Fries, 1828), and reported from France (Gillet, 1876), Finland (Karsten, 1879), Denmark (Lange, 1937; Lange and Hansen, 1950), and the Carpathians in Russia (Zerov and Peresipkin, 1979). Some of the specimens cited by Pilát (1935) under this name are

undoubtedly this species, but not that of Velenovský with strongly curved spores nor the collection from Germany on *Abies*. What Coker (1944) described as the first North American record of *P. unguicularis*, from North Carolina, was in fact *Hohenbuehelia pinacearum*.

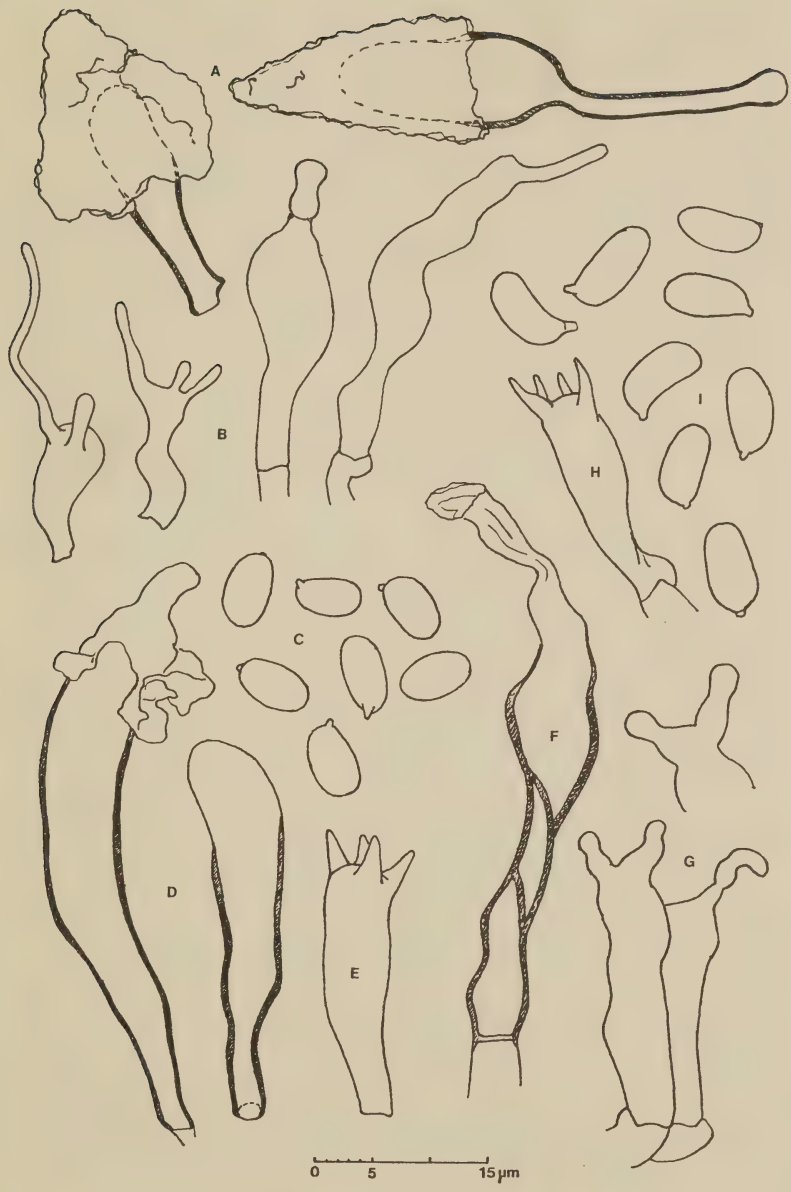
SPECIMENS EXAMINED: Canada: Manitoba: Victoria Beach, on old [decorticated dicot] wood, June 2, 1928, G.R. Bisby [#3906] et al., Dearness #6654 (lectotype of *Pleurotus atrocaeruleus* var. *minimus*; at DAOM). Nova Scotia: Highland Village, Colchester Co., on *Populus tremuloides*, June 17, 1954, A.G. Davidson, DAOM #46746. Ontario: Black Sturgeon Lake, Thunder Bay District, on *Populus*, June 11, 1976, S.A. Redhead, DAOM 159734; Dorset, Haliburton Co., on *Populus*, May 28, 1963, R.F. Cain, TRTC #40707; Lobo, on decorticated *Ulmus*, Nov. 8, 1931, J. Dearness #734 (at DAOM). Quebec: Cantley, Gatineau Co., on *Prunus serotina*, Apr. 28, 1985, J.H. Ginns, DAOM #191960; Tenaga, on *Populus*, May 1939, J.W. Groves and I. Mounce, DAOM #6998. Yukon Territory: Haines Junction, on *Populus*, Aug. 2, 1962, J. Holms, DAOM #93025. United States: New York: Knowersville [now Altamont, Helderberg Mountains], on decorticated wood, Oct. (no year), C.H. Peck s.n. (as *Pleurotus atropellitus*; NYS); Star Lake, on *Populus*, Sept. 7, 1974, J.H. Ginns, DAOM #155519.

OBSERVATIONS: *Hohenbuehelia unguicularis* is recognised by its cupulate to conchate, dark cap with silvery tomentum on its rear portion or apex, which may be drawn out into a pseudostipe, and by its gills that are silvery or pale tan when young and become dark in age. Microscopically, the peculiar, clavate metuloids that are brown in their lower portions and hyaline and thin-walled at their apices, are diagnostic. An unusual feature of this species is its occurrence in spring or early summer.

It is important to point out that *Hohenbuehelia unguicularis* (Fr.) Miller in this paper is based on *Pleurotus unguicularis* sensu Lange (1937), whereas *H. unguicularis* (Fr.) Miller (in Miller, in press) is based on *P. unguicularis* sensu Coker (1944), which is *H. pinacearum*.

Pleurotus unguicularis sensu Lange (1937) is clearly a

Figure 5 A-I: *Hohenbuehelia unguicularis*. A) Metuloids, and B) cheilocystidia of Dearness #734, 8 Nov., 1931. C-E: TRTC #40707. C) Basidiospores; D) metuloids; E) a basidium. F-I: DAOM #159734. F) A metuloid, twisted and collapsed; G) three cheilocystidia; H) a basidium; I) basidiospores.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Hohenbuehelia in that it has both metuloids and a *Nematoctonus* anamorph. The metuloids in this species, however, are very inconspicuous and have only previously been described in reference to *P. atrocaeruleus* var. *minimus* (Bisby et al., 1929). Lange and Hansen (1950) reported the presence of conical mounds of crystalline material in the hymenium, but they stated that "these seem without connection with the small hyaline cheilocystidia", and they missed the underlying metuloids. Their report confirms that *H. unguicularis* as treated herein is the same species as theirs. Zerov and Peresipkin (1979) transferred this name to *Hohenbuehelia*, but they said that cystidia were absent. Their transfer is invalid because they failed to cite the basionym.

This species has been very badly confused, from the time of its description. The description by Fries (1828) ran as follows: "*Pileo carnosulo laeviusculo, epidermoide viscosa, lamellis determinatis distantibus albidis, stipite brevissimo glabro. Pileus horizontalis, reniformis, convexo-planus, glaber vel villosulus, 2-4 lin. [4.2-8.5 mm] latus, raro 1/2 uncialis [12.7 mm] ... Duas legi formas, suis locis fideliter redeuntes; alteram pileo griseo in rimis Quercuum, alteram pileo aterrimo ad cortices Sorbi.*" It seems likely that Fries (1828) described two different fungi under *A. unguicularis*: the grey form on *Quercus*, which is likely *Resupinatus applicatus* (Pilát, 1935), and the black form on *Sorbus*, which is probably the same as *P. unguicularis* sensu Lange. For this reason it is necessary either to abandon the name *Agaricus unguicularis* Fries as a nomen confusum, or provide a neotype on which the name may be clearly based. Unfortunately, no fresh, mature collection was available to be designated as neotype at this time.

An excellent description and illustration of this species (as *Acanthocystis Leightonii* (Berk.) Konrad & Maublanc) is in Icones Selctae Fungorum, plate 309, figure III (Konrad and Maublanc, 1937). The type of *Agaricus Leightonii* Berk. (660. Montford Bridge, near Shrewsbury. Dec. 1, 1841. Rev W.A. Leighton, in K !), however, has the large spores (10.0-13.5 X 4.8-5.8 µm) and colouration of *Hohenbuehelia reniformis* (Meyer: Fr.) Singer, sensu Fries (1874).

The type specimen of *P. atrocaeruleus* var. *minimus* (June 2, 1928, G.R. Bisby [#3906] et al., Dearness #6654 at DAOM) is clearly conspecific (see Notes on Type Specimens).

Resupinatus alboniger (Pat.) Singer (1978: 17)
Figures 6 A-K, 7 A-D, 9 A-C.
Basionym: ***Pleurotus alboniger*** Patouillard, in Patouillard & de Lagerheim (1893: 126)
= ***Asterotus argentinus*** Singer, in Singer and Digilio (1953: 107), fide Singer (1978)
= ***Resupinatus argentinus*** (Sing.) Singer (1973: 30)
SELECTED DESCRIPTIONS AND ILLUSTRATIONS: North America: Pilát (1935: Tab. 20, fig. 1); Coker (1944: 77-78, pl. 42 centre, pl. 49, figs. 4-5); Miller and Manning (1976: 314, 317, 320, Figs. 2 k-m, 4). Europe: Kuehner (1980: Fig. 202 d) Africa: Pegler (1977: 106, Figs. 19/4 a-e). All above as ***Pleurotus silvanus***. South America: Singer (1978: 17-19).
DESCRIPTION: Fruit Bodies cupulate, pendent, 2-6 mm broad, ranging from grey-brown with glaucous or greyish fine tomentum, to flat black and glabrous, with at most a few white wisps. Lamellae radiating from centre or a point toward basal attachment, narrow, moderately spaced, dull brown, blackish brown or black, sometimes with frosted white margins. Cuticle a thin (up to 40 µm), dark brown crust, pebbly from encrusted hyphae of 2.5-6.0 µm diam., that have short, irregular knobs and branches and that become thick-walled, the walls up to 1.0 µm thick, hyaline or pale brown. Gelatinous Zone faintly brown in KOH, 80-750 µm thick (without cover-glass); hyphae pale brown, 1.2-3.0 µm diam., with clamps. Gill Trama continuous with gelatinous zone, or from narrow, less gelatinised tramal zone, of nearly hyaline, parallel, only slightly gelatinised hyphae 1-3 µm diam. Subhymenium narrow (15-20 µm thick), dark brown, of mostly parallel hyphae 1.2-2.5 µm diam. Hymenium nearly hyaline, 20-25 µm thick. Basidia 4-pronged, clavate-cylindric, 18-28 X 5.5-7 µm. Cheilocystidia variable, fusoid, clavate, lecythiform or pyriform, with or without irregular digitate projections, (11) 14-25 X 5-11 µm, most thin-walled, one with walls near apex 2.0 µm thick. Spores hyaline, inamyloid, smooth, elliptic-phaseoliform to cylindric-arcuate, (5.5) 5.8-7.5 (8.2) X (2.5) 2.7-3.5 (4.0) µm.
HABITAT: on dead, fallen branches and trunks of deciduous treees, with bark. Coker (1944) reported it on ***Liquidambar***, ***Lyriodendron***, ***Malus*** and ***Quercus***. Miller (in press) adds ***Nyssa*** and ***Prunus***.
DISTRIBUTION: Known from Alabama, Louisiana, Mississippi, North Carolina and Tennessee (Coker, 1944), Connecticut (Miller, in press) and Maine (Burt #141, FH). Singer (1978)

reported specimens from Ecuador, Venezuela, and Argentina. What appears to be this species has been reported from Tanzania (Pegler 1977) and France (Kuehner, 1980). SPECIMENS EXAMINED: United States: Maine: Harrison, on ***Acer pensylvanicum***, Sept. 1859, Burt #141 (FH). Mississippi: Ocean Springs, on ***Liquidambar***, Feb. 1887, F.S. Earle, Ellis and Everhart's N. Amer. Fungi #2008 (at DAOM). Without source data: VT #1364 (from O.K. Miller, Jr., VPI) fruiting in culture, RGT #840810/01. Ecuador: Ravine near Quito, on [dicot] twigs, Feb. 1, 1892, Lagerheim s.n. (FH; type of ***P. alboniger***). Holland: Veere, on ***Ribes grossularia***, winter 1830, M.A. Libert, Plantae Crypt. Arduennae #19-B (at DAOM). OBSERVATIONS: The dark, nearly glabrous or hoar-frosted pileus, and entirely resupinate, cupulate habit of this species, and its occurrence on hardwoods, eliminate all others with which ***R. alboniger*** might be confused except ***Hohenbuehelia nigra***. Microscopically, ***R. alboniger*** can be recognised by the lack of metuloids, and the presence of diverticulate cheilocystidia and diverticulate cuticular hyphae with thick, brown walls. ***Resupinatus alboniger*** shows how closely related ***Resupinatus*** is to ***Hohenbuehelia***, but its lack of a ***Nematoctonus*** state or nematophagous habit, its diverticulate cheilocystidia and cuticular hyphae indicate that it is a ***Resupinatus***, allied to ***R. applicatus*** and ***R. striatulus***.

The type specimen, and Libert #19-B, have quite strongly curved spores and apparently lack the fusoid or pyriform cheilocystidia found in the North American specimens cited. These two specimens were also conspicuously white-tomentose, as was the fruit body of VT #1364 that formed in culture. All specimens were otherwise similar and are considered to be conspecific. Singer (1978) noted that the cheilocystidia of ***R. alboniger*** are versiform, ranging from filamentous to clavate, ventricose, utriform or

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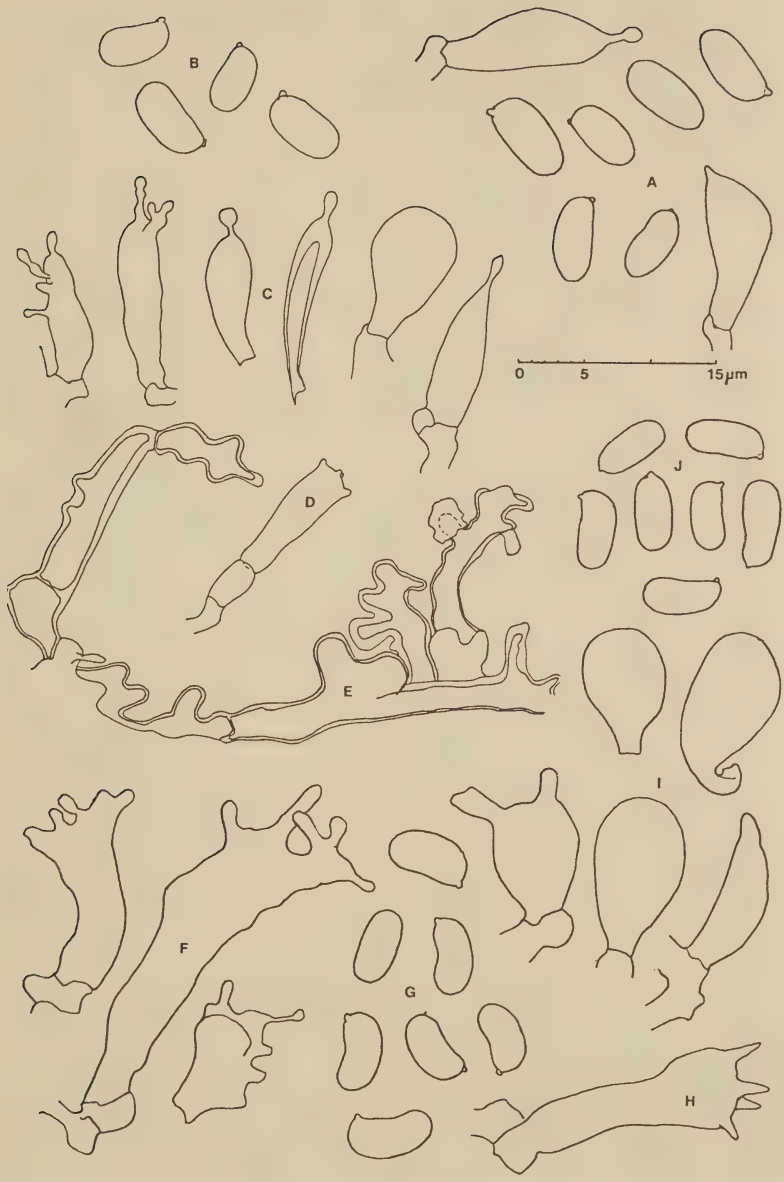
Figure 6 A-J: ***Resupinatus alboniger***. A) Blake 1859 (Burt #141, FH), basidiospores dnd two cheilocystidia. B-E: VT #1364 fruiting in culture (RGT #840810/01). B) Basidiospores; C) six cystidia, showing wide range in shape; D) a young basidium; E) diverticulate, thick-walled cuticular hyphae. F-H: Libert Pl. Crypt. #19-B (at DAOM). F) Cheilocystidia; G) basidiospores; H) a basidium. I-J: Ellis & Everhart N. Amer Fungi #2008 (at DAOM). I) Cheilocystidia; J) basidiospores.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ampullaceous, and entire or with apical or lateral diverticulae. Libert #19 at DAOM (as *Agaricus applicatus* Batsch) consists of two parts: part A, "*ad truncos*", which is *Resupinatus striatulus* (Pers.: Fr.) Murr.; and part B, "*ad ramos putridos Ribis grossulariae*", which is *R. alboniger*.

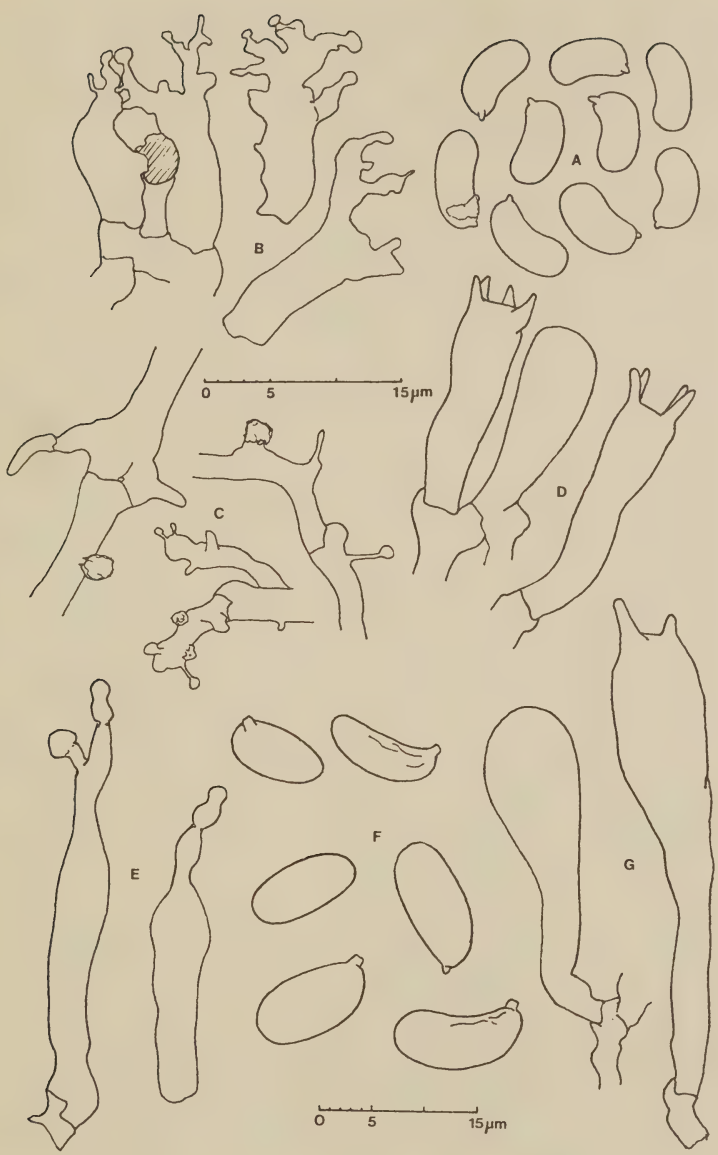
NOTES ON TYPE SPECIMENS

Pleurotus alboniger Patouillard, in Patouillard and Lagerheim (1893: 126). Figures 7 A-D, 9 A, C. ("*Pleurotus alboater* Pat.", typographic error in Singer, 1952: 178; copied in Dennis, 1970: 48)

TYPE SPECIMEN: Quito, "fevrier 1890", leg. Lagerheim, sur brindles, FH. A note in the packet states: "couleur naturelle non changée. Ravine prés Quito 1 Fevr. 92 Lagerh". The paratype (Singer, 1978) is from Cotocallao, Ecuador, and was also collected in February, 1892 by Lagerheim (FH).

Pileus (dry) cupulate, pendent from slight umbilicus on apex, 2-3 mm diam., surface heavily pruinose, now greyish white (A-B1) to grey-brown (5B2) at apices in some. Flesh chitinous, deep warm brown (ca. 5E5). Lamellae radiating from centre, subdistant, moderately narrow, dark brown (5F5) on their faces, with densely white-pruinose margins. Cuticle pale brown (KOH), a dense, deep tangle of hyphae (1.5) 2-3 (4) µm diam., with knobs and tapering branchlets, becoming obscured by coarse masses of yellowish or brownish encrusting material. Gelatinous Zone 50-70 µm deep, hyaline, a mostly-horizontal tangle with a few ascending hyphae, refractive portion of hyphae (dark in phase) 0.8-2.0 (2.5) µm diam., the walls strongly gelatinised, outer diam. to 10 µm. Trama narow, 10-25 µm deep, pale to dark brown (KOH), descending to form subhyaline to hyaline, +/- parallel gill trama, of hyphae 1.5-3.0 µm diam. Basidia 4-spored, clavate, hyaline, 18-28 X 5.5-6.5 µm. Cheilocystidia forming a wide sterile band, cylindric- or clavate-diverticulate, 13-23 X

Figure 7 A-D: *Pleurotus alboniger*, Lagerheim s.n., Quito, Feb. 1, 1892 (holotype, FH). A) Basidiospores; B) cheilocystidia; C) cuticular hyphae; D) basidia and a basidiole. E-G: *Agaricus leightonii*, W.A. Leighton s.n., Montford Bridge near Shrewsbury, Dec. 1, 1841 (holotype, K). E) Two cheilocystdia; F) basidiospores; G) a basidium and basidiole.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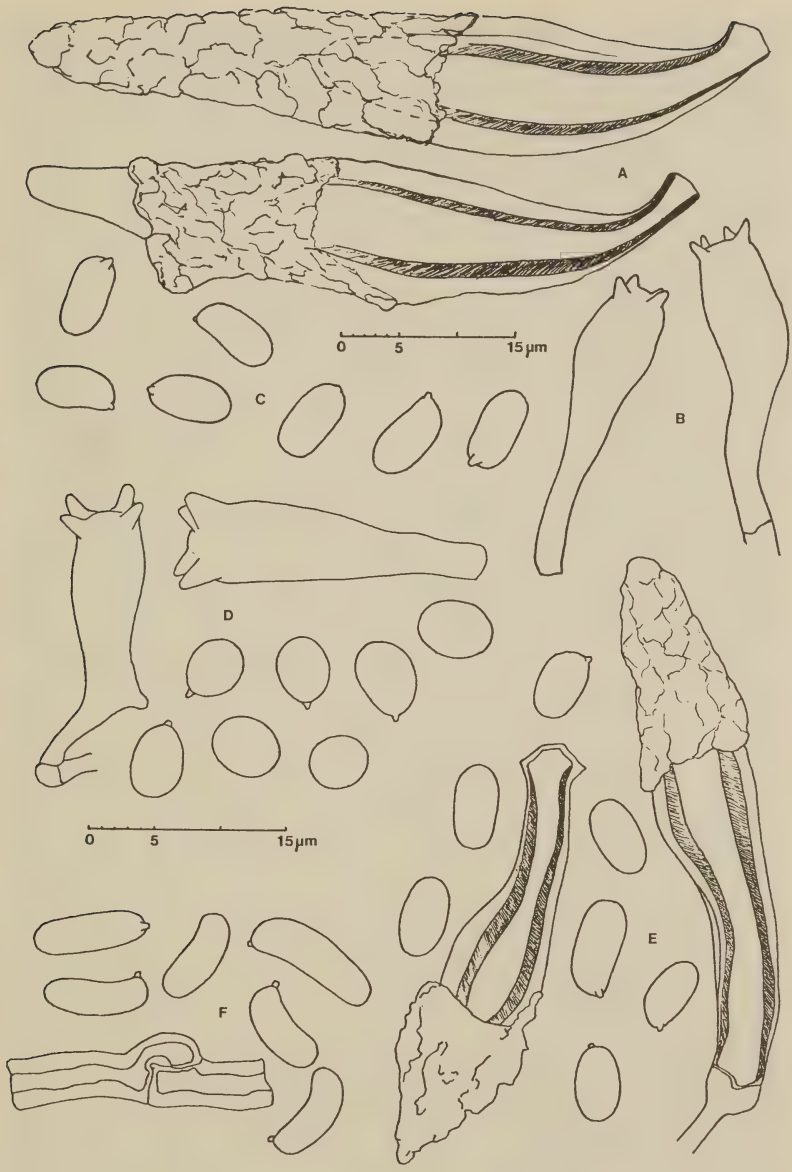
3.5-5.5 µm. Basidiospores hyaline, inamyloid, smooth, cylindric-phaseoliform, many quite curved, (5.8) 6.0- 7.5 (8.0) X (2.5) 2.8-3.2 (3.5) µm.
OBSERVATIONS: Lanceolate cheilocystidia, common in North American collections of *R. alboniger* were not found in the type collection. Otherwise, however, the type greatly resembled the fruit bodies formed in culture by VT #1364.

Pleurotus atrocaeruelus (Fr.) Gillet var. ***minimus*** Dearness & Bisby, in Bisby et al. (1929: 104). Figure 8 A-C.
TYPE SPECIMEN: Victoria Beach, Manitoba, Canada, on old wood, June 2, 1928, G.R. Bisby (#3906) et al., Dearness #6654, at DAOM; hereby designated lectotype.
Fruit Bodies dimidiate or broadly cupulate, dorsally attached, 3-8 mm broad (dry), margins blackish, bases somewhat buffy-tomentose. Lamellae radiating from base or near centre, moderately thick and well-spaced, now blackish-brown. Cuticle a brown crust 10-12 µm deep, of smooth, brown-walled hyphae 3-6 µm diam., above which are hyaline to medium brown tomentum hyphae 100-200 µm long X 2-4 µm. Gelatinous Zone 100-120 µm deep, hyaline, an ascendant tangle of clamped hyphae 1.5-3.5 µm diam. Trama 150-220 µm deep, pale brown, hyphae tightly packed, 3-5 µm diam., with gelatinised walls to 2 µm thick. Lamellar Trama subhyaline, gelatinised, slightly interwoven, hyphae 3-5 µm diam. Subhymenium dark brown, 20-40 µm deep, hyphae 2-6 (7) µm diam. Hymenium medium brown, 30-50 µm deep. Metuloids lanceolate, brown-walled at their bases, hyalina at acute apices, (25) 55-90 X (4) 10-15 µm, heavily encrusted at apices. Cheilocystidia not seen. Basidia 4-pronged, clavate, 28-38 X 6.5-8 µm. Spores hyaline, inmamyloid, narrowly phaseoliform, smooth, 7-8.0 (8.5) X 3.5-4.2 (4.5) µm.
OBSERVATIONS: This specimen clearly represents *Hohenbuehelia*

Figure 8 A-C: ***Pleurotus atrocaeruleus*** var. ***minimus***, G.R. Bisby #3906, June 2, 1928 (lectotype, Dearness #6654 at DAOM). A) Two metuloids; B) two basidia; C) basidiospores. D: ***Pleurotus atropellitus***, E.C. Howe s.n., Fort Edward, N.Y. (lectotype, NYS), basidia and basidiospores. E: ***Hohenbuehelia unguicularis***, Peck s.n., Knowersville, Helderberg Mountains, N.Y. (as ***P. atropellitus***, NYS), metuloids and basidiospores. F: ***Agaricus blakei***, Curtis #6289 (isotype, FH), basidiospores and gelatinised hypha from gill trama.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unguicularis. Particularly interesting are the notes by Bisby in the specimen packet, "cystidia abundant, 10-12 X 40-60 [µm], rough [apex], dark brown base!" This is the only known previous record of metuloids in *H. unguicularis*.

Bisby et al. (1929) reported that the spores of *P. atrocaeruleus* var. *minimus* were 7-10 X 4-5 µm, but this includes the measurements of a specimen collected June 13, 1928. This specimen (Victoria Beach, Manitoba, on old wood, G.R. Bisby [#3906a] and A.H.R. Buller, also Dearness #6654, at DAOM) was referred to by Dearness, in a note on the packet, as the "second sending". This specimen has pale lamellae, hyaline, thick-walled, lanceolate metuloids, and spores (7.2) 7.5-10 X 4.0-5.0 (5.2) µm, and is *Hohenbuehelia atrocaerulea* (Fr.) Singer.

Pleurotus atropellitus Peck (1886: 65)

Figures 8 D, 9 D-E.

TYPE SPECIMEN: *Pleurotus atropellitus* was treated as a synonym of *Pleurotus applicatus* (*Resupinatus applicatus*) by Coker (1944). Coker accepted the first specimen named by Peck in the original description as the type, but did not specifically designate it as lectotytpe. The box containing this specimen has been labelled "TYPE". This collection (Fort Edward, E.C. Howe, NYS) is *Resupinatus applicatus* and has the charactersistic subglobose spores of that species (5.5-6.2 X 4.4-5.5 µm, subglobosa, hyaline, inamyloid, and smooth, Figs. 8 D, 9 E).

In the original description of *P. atropellitus* (Peck, 1886), the following words and phrases were printed in italics: "[pileus] villose tomentose except on the margin, ... blackish brown or black, ... [lamellae] close, blackish

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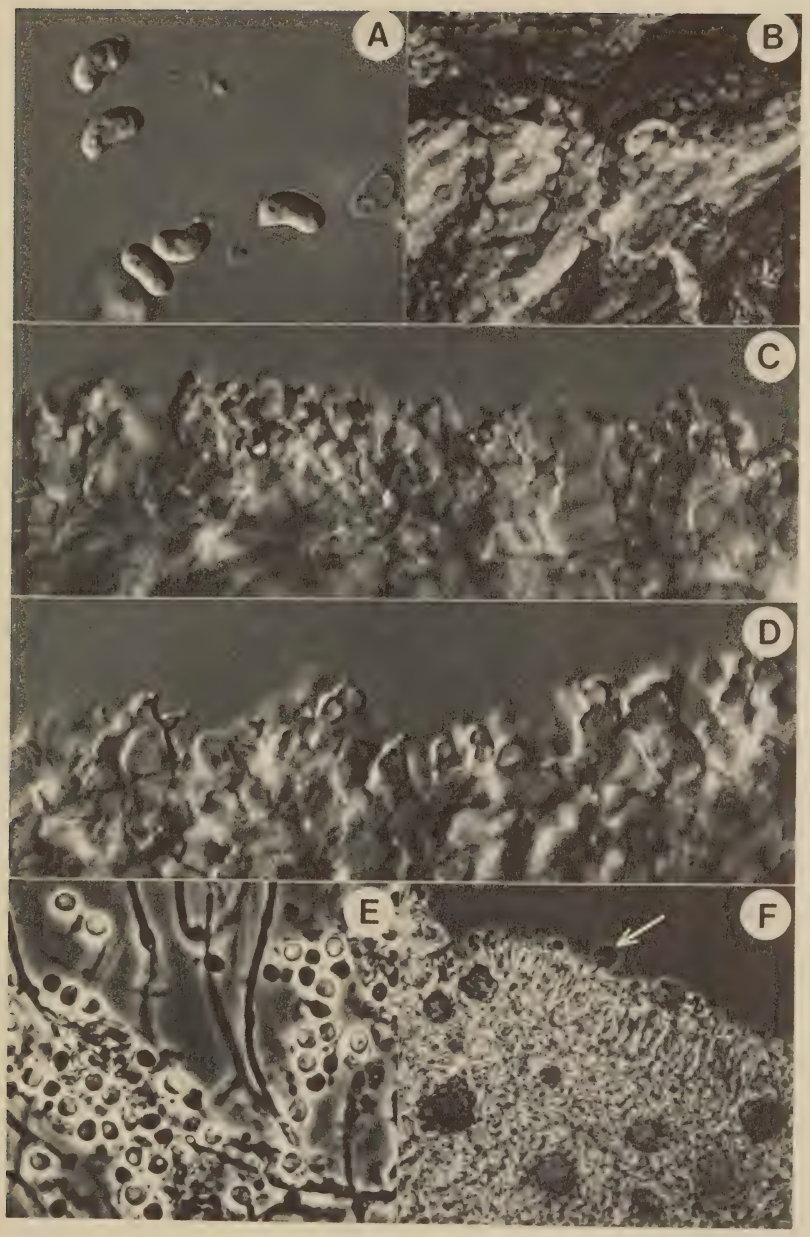
Figure 9 A-C: *Resupinatus alboniger*. A) Basidiospores of Lagerheim s.n., Quito, Feb. 1, 1892 (holotype of *Pleurotus alboniger*, FH), X 1250; B) cuticle of Burt #141 (FH), showing knobbed and encrusted cuticular hyphae, X 660; C) gill edge of Lagerheim s.n. Quito, Feb. 1, 1892, showing diverticulate fringe of cheilocystidia, X 1150. D-E: *Resupinatus applicatus*, E.C. Howe s.n., Fort Edward, N.Y. (lectotype of *Pleurotus atropellitus*, NYS). D) Gill edge with diverticulate cheilocystidia, X 1280; E) basidiospores on cuticle, X 500. F: *Agaricus leightonii* (type, K), gill edge showing cheilocystidium with apical mucoid ball (arrow), and crystalline caps of metuloids, X 300.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brown or black, ... [spores] subelliptical". The spore size was given as ".0003 to .00035 in long, .00016 to .0002 broad" [7.6–8.9 X 4.1–5.0 µm]. No type was designated, but specimens were reported from "decaying wood and bark, both of frondose and acerose trees. Fort Edward, E.C. Howe. Buffalo, G.W. Clinton. Maryland, Helderberg and Adirondack Mountains."

Of these cited specimens, the one from the Adirondack Mountains ("Bennetts, on Spruce", NYS) can be eliminated as a choice for lectotypification, since the pileus is not at all villose-tomentose. It represents a 2-spored collection of *Hohenbuehelia pinacearum* (Fig. 4 A–E). Similarly, the Clinton collection from Buffalo (BUF #43355) can be rejected as a possible lectotype, since the fruit bodies are cupulate and reddish-brown, the gills are pinkish-brown, and the spores subglobose; it is a collection of *Resupinatus striatulus* (Pers.: Fr.) Murrill. The Fort Edward, Maryland, and Helderberg Mountains collections all match the macroscopic characters of the original description, but only the collection from the Helderberg mountains has elliptical spores (5.5–7.0 X 2.9–3.5 µm, Fig. 8 E). These spores are, however, narrowly elliptical, not subelliptical as mentioned in the original description. Since Peck regarded *P. atropellitus* as the North American equivalent of *P. applicatus*, and since it is possible that he erred in transcription of the spore lengths, the Fort Edward collection by E.C. Howe is accepted as, and hereby designated, lectotype of *P. atropellitus* Peck. A brief description of this collection follows.

Pileus (dry) cupulate to flabelliform or dimidiate, up to 4 mm diam., vinaceous brown to blackish brown, with dense, coarse, off-white tomentum over basal area. Lamellae radiating from point of attachment, close, narrow, brownish to black, most with frosted white margins. Basidia 4-spored, clavate, 18–26 X 6–7.2 µm. Basidiospores (from gill fragments) hyaline, inamyloid, smooth, subglobose, 5.5–6.2 X 4.4–5.5 µm.

Agaricus blakei Berkeley and Curtis (1859: 288)
Figure 8 F.

TYPE SPECIMEN: United States: Maine, [1859], Rev. J. Blake #105, "Ad ramul. dej. Abietis", Curtis #6289, FH, K. One basidiocarp, in good condition, is in FH and one, poorly dried, at K.

Pileus dimidiate, (now flattened), dull magenta, white-

pruinose toward margin and with buffy tomentum over disk, stipe none. Lamellae radiating from point of attachment, narrow, subdistant, pinkish-brown, somewhat intervenose toward pileus margin. Lamellar Trama hyaline, gelatinised, of interwoven hyphae (1.5) 2-5 µm diam, with walls gelatinised to 2 µm thick, with clamps. Basidia 4-spored, hyaline, clavate, 18-21 X 5.5-6.5 µm. Cystidia none seen. Basidiospores cylindric to somewhat allantoid, amyloid, smooth, (6.6) 7.2-9.6 (10.0) X 2.2-3.4 (3.6) µm.
OBSERVATIONS: The colouration of the fruit bodies, the habitat, and the long, cylindric, amyloid spores clearly identify this collection as *Panellus violaceofulvus* (Batsch: Fr.) Singer. This collection represents the third known collection of *P. violaceofulvus* from North America. The other two collections are from Anticosti Island, Quebec, Canada (Miller, 1970) and Gros Morne National Park, Newfoundland, Canada (Sept. 24, 1983, S.A. Redhead, DAOM #187858). All collections are on *Abies*.

Agaricus Leightonii Berkeley (1844: 343)
Figures 7 E-G, 9 F.
TYPE SPECIMEN: England: Montford Bridge near Shrewsbury, Dec. 1, 1841, Rev. W.A. Leighton, K. The substrate is corticated hardwood.
Pileus (dry) cupulate, up to 7 mm diam., dorsally attached, dark reddish brown beneath a greyish bloom at the margin, the disk entirely shaggy-tomentose with buffy hairs. Lamellae radiating from a near-central point on underside, moderately distant and narrow, deep cream to reddish, very finely frosted under 10 X. Lamellar Trama nearly parallel, hyaline, slightly gelatinised, hyphae 2-3 (4.5) µm diam. Basidia few mature; one dubiously 2-pronged, other (collapsed) apparently 4-pronged, basidioles clavate, 21-36 (48) X 6-7.2 (8.2) µm. Cheilocystidia fusoid-capitate, 32-44 X 4.0-5.5 (7) µm, with a gloeoid head 6-12 µm diam. produced by stubby hour-glass secretory cells 4-4.8 X 1.8-2.2 µm. Metuloids conical crystalline mounds clearly visible in face view, 12-18 µm diam., metuloids themselves hyaline, clavate, or with tapering necks, magenta in cresyl blue, inamyloid, in a squash mount collapsing and not distinctive, 18-36 X 5-8.4 µm. Basidiospores elliptic, hyaline, inalmyloid, smooth (many collapsed), 10.0-13.5 X 4.8-5.8 µm.
OBSERVATIONS: The metuloids and the leptocystidia with hour-glass secretory cells of this collection clearly indicate that *Agaricus leightonii* is a species of *Hohenbuehelia*. The

metuloids, however, are very inconspicuous, hardly protruding from the hymenial surface. These metuloids were overlooked by Orton (1960: 181), who made the new combination ***Resupinatus leightonii*** (Berk.) Orton. This specimen has the colouration and large spores characteristic of ***Hohenbuehelia reniformis*** (Meyer: Fr.) Singer, sensu Fries (1874) and M.C. Cooke (1883).

Agaricus mustaliensis Karsten (1876: 99)
Figure 10 D-G.
TYPE SPECIMEN: Mustalia [Finland], "pa tallbark" [***Pinus sylvestris***], Dec. 8, 1865, P.A. Karsten, Fungi Fenniae Exsccati #605. A portion of this exsiccati at FH was studied.
Pileus orbicular, 7 X 6 mm, broadly attached, margin black and glabrous, entire disk covered with thick (0.5 mm deep) mat of creamy-white tomentum (probably adpressed basal mycelium). Lamellae radiating from point of attachment, narrow, subdistant, black, with white margins, finely frosted under 10 X. Cuticle a cutis of brown, smooth-walled hyphae with clamps, 2.8-8.5 µm diam., epicuticular hyphae hyaline, smooth, > 1000 µm long, (1.2) 1.8-5.0 µm diam., mostly thin-walled but some with walls up to 0.75 µm thick, with scattered hour-glass secretory cells 4-5 X 1.5-1.8 µm, producing mucoid balls 5-7.5 µm diam. Basidia 4-spored, hyaline, clavate, (21) 28-36 X 6-7 µm. Cheilocystidia numerous, clavate-capitate, 23-34 X 5-8 µm, most with a mucoid cap (before squash) 5-7.5 µm diam., the hour-glass cells 4-6 X 1.5-2 µm. Metuloids prominently projecting from hymenium, lanceolate, 42-72 X 6.6-12.3 µm, with a tri-layered wall, the middle layer dark brown (KOH) and the inner and outer layers hyaline, capped with a conical cone of hyaline crystalline material. Basidiospores hyaline, inamyloid, elliptic to elliptic-phaseoliform, 8.2-9.4 (10.4) X 4.2-5.0 µm.
OBSERVATIONS: ***Agaricus mustaliensis*** is clearly a ***Hohenbuehelia***, and is very similar to ***H. nigra*** (Schw.) Singer, from which it differs in its habitat and tomentose

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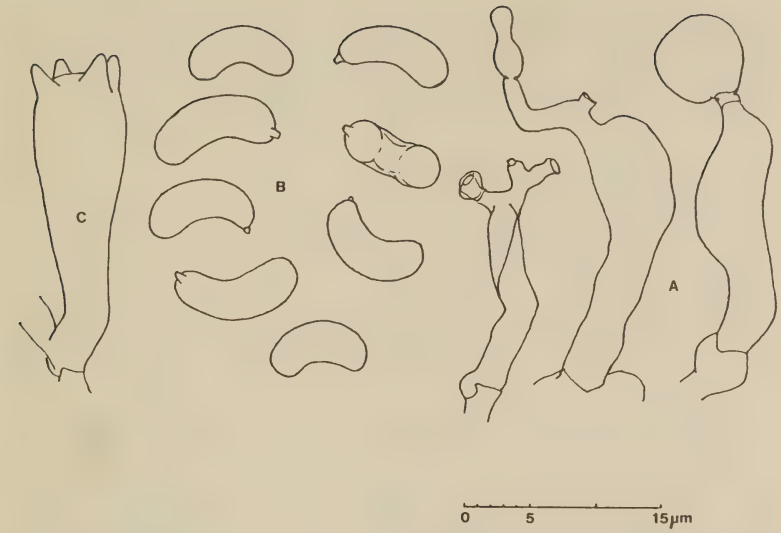
Figure 10 A-C: ***Agaricus sylvanus***, PAD #3644 (type). A) Cheilocystidia; B) allantoid basidiospores; C) a basidium. D-G: ***Agaricus mustaliensis***, Fungi Fenniae #605 (isotype, FH). D) Basidiospores; E) cheilocystidia; F) basidium; G) metuloids.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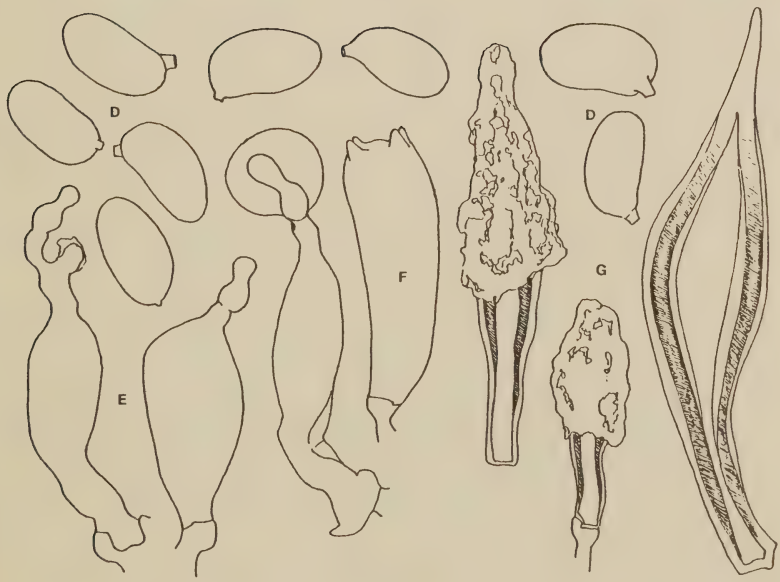
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cap surface. No other known species of *Hohenbuehelia* has the combination of characters of *Agaricus mustaliensis*, so the new combination *Hohenbuehelia mustaliensis* (Karsten) Thorn, comb. nov. (basionym *Agaricus mustaliensis* Karsten, Mycologica Fennica 3: 99, 1876) is proposed.

Agaricus (*Pleurotus*) *sylvanus* Saccardo (1877: 1)
Figure 10 A-C.
TYPE SPECIMEN: Italy: Selva, Treviso, on *Clematis vitalba*, March 1877, P.A. Saccardo, PAD #3644.
Pileus cyphelloid to cupulate or conic-pendent, 1-7 mm broad (dry), blackish-brown, some with olive tints, white-furfuraceous. Lamellae (few remaining) radiating from near-central point on underside, distant or subdistant, narrow, now beige. Cuticle a shallow cutis of brownish hyphae with abundant yellowish crystalline and amorphous encrusting material, and some coarsely spiral-encrusted as well, 2-4 µm diam., with a few cylindric branchlets 1-1.5 µm diam., and hour-glass 4.5 X 1.7 µm, with mucoid ball 6 µm diam. (only one seen). Gelatinous Zone hyaline, of tangled hyphae, 1.5-4.0 µm diam., those adjacent to cuticle with fine spiral encrustation. All hyphae with clamp connections. Lamellar Trama hyaline. Basidia 4-spored, hyaline, clavate (many collapsed) 21-30 X 6.2-8 µm. Cheilocystidia hyaline, 20-35 X 4.5-6 µm, of two types - one fusoid, tapering nearly to a point, then with a fine cap 1-1.5 µm diam.; the other fusoid-capitate with well-formed hour-glass at apex, 4-5.5 X 1.5-2 µm, mucoid ball 5-6.5 µm diam. Metuloids not seen (not examined in Cresyl Blue) Basidiospores hyaline, inamyloid, broadly allantoid, smooth, 7.5-9.3 (not counting curve) X 2.8-3.6 µm.
OBSERVATIONS: The habitat and curved basidiospores, as well as the original description by Saccardo (1877), clearly identify this specimen as identical to *Agaricus cyphelliformis* Berkeley (1837). The hour-glass secretory cells found on the cuticle and cheilocystidia indicate that this species is a *Hohenbuehelia*, as has been noted by Miller (in press). Further evidence that *A. cyphelliformis* is a *Hohenbuehelia* is provided by the observation of metuloids in two Canadian collections of that species (above), and the nematophagous ability and *Nematoctonus* state of cultures cultures of these collections (Thorn, unpublished).

CONCLUSIONS

Four distinct species have been treated under the

epithet *Pleurotus silvanus* (Sacc.) Saccardo (1887). The type of *Agaricus sylvanus* Saccardo (1877) is a specimen of *Hohenbuehelia cyphelliformis* (Berk.) Miller. *Pleurotus silvanus* sensu Josserand (1933) is *Hohenbuehelia pinacearum* Thorn, which has also been commonly misidentified as *P. atropellitus* Peck (1886), or *P. unguicularis* (Coker, 1944, Miller and Manning, 1976). *Pleurotus silvanus* sensu Coker (1944), and Miller (in press; Miller and Manning, 1976) is *Resupinatus alboniger* (Pat.) Singer (1978). *Hohenbuehelia unguicularis* (Fr.) Miller has been misidentified as *Resupinatus silvanus* by Thorn and Barron (1984) and others. The elucidation of the taxonomy of this group was aided by studies on the cultural characters and biology of these fungi, which will be reported elsewhere.

ACKNOWLEDGEMENTS

I wish to thank Dr. G.L. Barron, under whose supervision much of this work was done as part of an MSc thesis project, for his encouragement and patience; Dr. J.A. Parmelee (DAOM), and Dr. J. Krug (TRTC) for the loan of specimens and for facilities provided while I visited these herbaria; Dr. J.H. Haines (NYS), Dr. M. Josserand of Lyon, France, Dr. G.G. Lorenzoni (PAD), Dr. D.H. Pfister (FH), and Dr. D.A. Reid (K) for the loan of type and authentic specimens; Dr. O.K. Miller, Jr. (VPI) and Dr. R. Singer (F) for cultures, specimens and valuable correspondence regarding *Hohenbuehelia*; and Mr. G. Whitney, superintendent of Algonquin Provincial Park, Ontario, for permission to collect there. This project was funded in part by an operating grant to Dr. Barron from the Natural Sciences and Engineering Research Council of Canada. This paper was reviewed by Dr. J.H. Ginns and Dr. S.A. Redhead (DAOM).

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MYCOTAXON

Vol. XXV, No. 1, pp. 67-83 January-March 1986

BASIDIOMYCETES THAT DECAY GAMBEL OAK IN SOUTHWESTERN COLORADO: II

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SUMMARY

Twenty additional Basidiomycetes that decay **Quercus gambelii** Nutt. in southwestern Colorado are illustrated and described.

In a previous paper (Lindsey, 1985) thirty wood-rotting Basidiomycetes in the orders Tremellales, Dacrymycetales, Aphyllophorales, and Agaricales were described. This paper continues a series which will culminate with a comprehensive key to all the species found in this area. Microscopic techniques were described in the initial paper of the series (Lindsey, 1985). Numerical color names are from Munsell's Book of Color (Munsell, 1976); descriptive names are the author's.

List of Additional Species that Decay Gambel Oak

AMPHINEMA BYSSOIDES (Fr.) John Erikss., Symb. Bot. Upsal. XVI:1, p. 112. 1958.
Basidiocarps effused-resupinate, farinaceous, separable, dull golden-brown (2.5Y 7/4); margin abrupt. **Hyphal system** monomitic; subicular hyphae thin- to slightly thick-walled, rather rigid in appearance, abundantly nodose-septate and frequently branched, some with fine regular encrustations, 2-3.5 µm diam. **Cystidia** projecting up to 80 µm, cylindric, hyphoid, with frequent clamps and fine encrustations, moderately thick-walled, up to 85 x 4-5 µm. **Basidia** cylindric to clavate, 4-sterigmate, with a basal clamp, 14-15 x 4-4.5 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, ellipsoid, 3-3.5 x 1.5-2.5 µm. **Voucher specimen** - JPL 1308.

ATHELIA COPROPHILA (Wakef.) Jülich, Willdenowia 7:66. 1972.
Basidiocarps very thin, pellicular, tuberculate, cracking extensively upon drying to expose the substratum, grayish-white (2.5Y 8/2); margin indistinct, thinning out. **Hyphal system** monomitic; subicular hyphae nodose-septate, thin-walled near the hymenium, becoming more thick-walled near the substratum, 2.5-3.5 µm diam. **Sterile hymenial elements** lacking. **Basidia** short-clavate, 4-sterigmate, with a basal clamp, 12-15 x 6-7 µm. **Basidiospores** globose to subglobose, strongly apiculate, hyaline, smooth, negative in Melzer's reagent, 3.5-4 x 4-5 µm. **Voucher specimen** - JPL 1290.

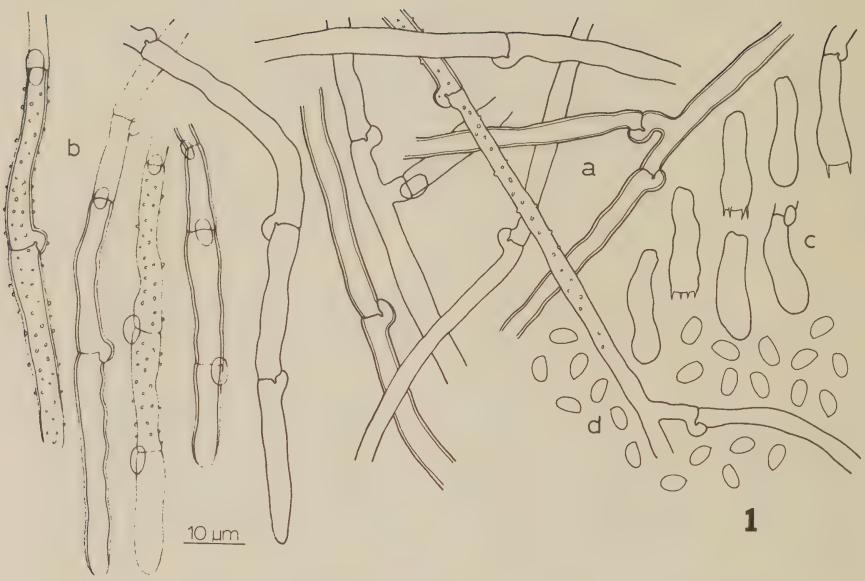

Fig. 1. **Amphinema byssoides.** (JPL 1308). a) subicular hyphae; b) cystidia; c) basidia; d) basidiospores.

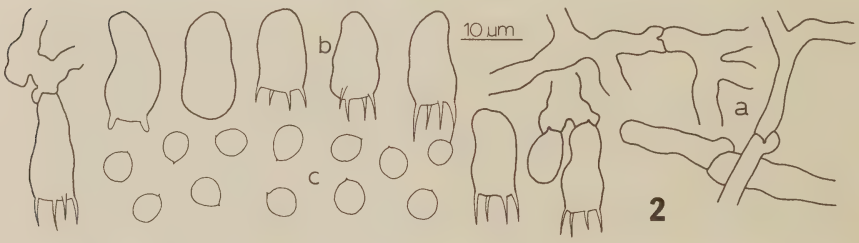

Fig. 2. **Athelia coprophila.** (JPL 1290). a) subicular hyphae; b) basidia; c) basidiospores.

CERIPORIA RETICULATA (Fr.) Dom., Acta. Soc. Bot. Pol. 32:732. 1963. **Basidiocarps** annual, resupinate, becoming effused up to 6 cm, separable, soft, drying to a pinkish orange (near 10YR 8/4); tubes 2-4 per mm, often only a shallow reticulum, with thick dissepiments. **Hyphal system** monomitic; subicular hyphae thin- to slightly thick-walled, simple-septate, with occasional right-angle branching, 2.5-5 µm. **Sterile hymenial elements** lacking. **Basidia** clavate to short-clavate, 4-sterigmate, with a simple septum at the base, 16.5-20 x 6-7 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, reniform to broadly allantoid, 6.5-10 x 3-4 µm. **Voucher specimen** - JPL 1121.

Fig. 3. **Ceriporia reticulata.** (JPL 1121). a) subicular hyphae; b) basidia; c) basidiospores.

CERIPORIA TARDA (Berk.) Ginns, Mycotaxon 21:326. 1984.
Basidiocarps annual, resupinate, effused up to 3 cm, soft, cream colored with pink areas when fresh, drying to a dull cream; pores shallow, irregular, often more of a shallow reticulum, 4-6 per mm; margin broad to abrupt, white, minutely fimbriate to floccose. **Hyphal system** monomitic; hyphae hyaline, simple-septate, thin-walled in the hymenial region, becoming slightly thick-walled and broader in the subiculum, 3-6 µm diam. **Sterile hymenial elements** lacking. **Basidia** short-clavate, 4-sterigmate, with a simple septum at the base, 12-14 x 4-6 µm. **Basidiospores** hyaline, smooth, cylindric-ellipsoid, negative in Melzer's reagent, 4-4.5 x 2-2.5 µm. **Voucher specimen** - JPL 1289.

CERIPORIOPSIS MUCIDUS (Pers.:Fr.) Gilbn. et Ryv., Mycotaxon 22: 364. 1985.
Basidiocarps annual, effused, cream colored (near 10YR 9/4); pores angular, edges becoming lacerate to fimbriate, 2-4 per mm; margin abrupt to broad, white, fimbriate, with weak rhizomorphic development. **Hyphal system** monomitic; hyphae thin- to very thick-walled, nodose-septate, frequently branched, 2.5-4.5 µm diam. **Sterile hymenial elements** lacking. **Basidia** clavate to cylindric-clavate, 4-sterigmate, 15-17 (-32) x 5-6 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, ovoid to ellipsoid, 3.5-4 x 2-2.5 µm. **Comments** - Basidia in this fungus often are formed directly as lateral branches on hyphae (see figure); others form at hyphal apices and become greatly elongated and distorted, having a cylindric, slender basal portion and an apex which may be at an angle to the axis of the basidium. **Voucher specimen** - JPL 1298.

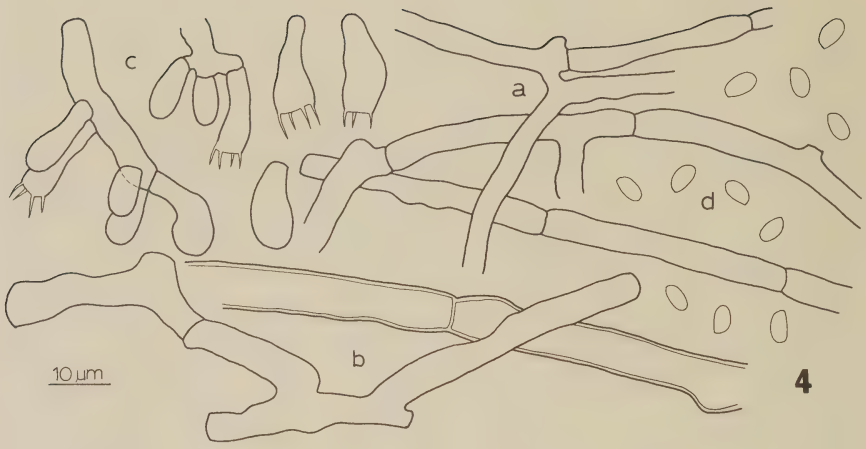

Fig. 4. **Ceriporia tarda.** (JPL 1289). a) subicular hyphae near hymenium; b) deep subicular hyphae; c) basidia, some in loose candelabrums; d) basidiospores.

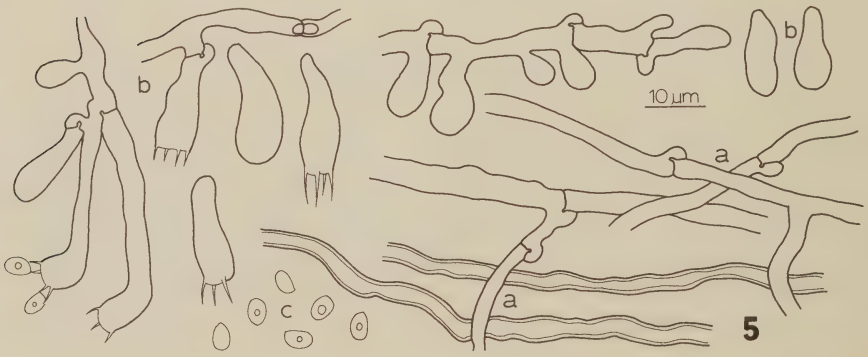

Fig. 5. **Ceriporiopsis mucidus.** (JPL 1298). a) subicular hyphae, showing thick-walled fragments without clamps that could be mistaken for skeletal hyphae; b) basidia, both laterally and terminally produced; c) basidiospores.

FIBULOMYCES MUTABILIS (Bres.) Jülich, Willdenowia 7:182. 1972. **Basidiocarps** bright white, effused, easily separable, smooth; margin white, floccose to fimbriate. **Hyphal system** monomitic; subicular hyphae nodose-septate, thin-walled near the hymenium, becoming more thick-walled near the substrate, 2-4 µm diam. **Sterile hymenial elements** lacking. **Basidia** narrowly cylindric-clavate, 4-sterigmate, with a basal clamp, 19-24 x 3.5-4.5 µm. **Basidiospores** ellipsoid,

hyaline, smooth, negative in Melzer's reagent, 3.5-4.5 x 2-2.5 µm. **Voucher specimen** - JPL 1174.

GLOEOPHYLLUM TRABEUM (Pers.:Fr.) Murr., N. Am. Fl. 9:129. 1908. **Basidiocarps** annual, sessile, effused-resupinate to effused-reflexed and strongly pileate, pilei often confluent; upper surface of pileus dirty gray-brown (near 10YR 6/2 to 10YR 3/4), tomentose but becoming glabrous upon weathering; pore surface more golden, 10YR 5/4, the pores initially elongated and variable, becoming radially lamellate with age; context concolorous with pileus, 1-2 mm thick, staining dark brownish-black in KOH. **Hyphal system** dimitic; generative hyphae hyaline, thin-

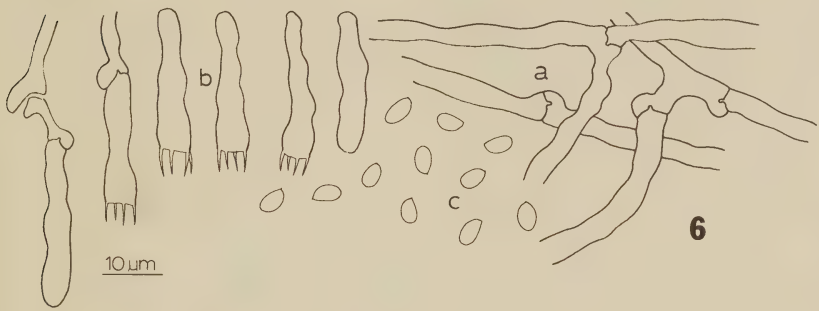

Fig. 6. **Fibulomyces mutabilis.** (JPL 1174). a) subicular hyphae; b) basidia; c) basidiospores.

Fig. 7. **Gloeophyllum trabeum.** (JPL 1313). a) generative hyphae; b) lightly pigmented skeletal hyphae; c) hyphoid cystidia; d) basidia; e) basidiospores.

walled, nodose-septate, 2.5-3.5 µm diam; skeletal hyphae with golden pigment, thick-walled, aseptate, rarely branched, 2.5-3.5 µm diam. **Cystidia** inconspicuous, barely projecting, thin-walled and almost hyphoid, 25-30 x 3-5 µm. **Basidia** clavate, 4-sterigmate, 23-26 (-45) x 5-7 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, cylindric, 7.5-8.5 x 3.5-4.5 µm. **Comments** - This is the first brown-rot fungus reported on Gambel oak in this series. **Voucher specimen** - JPL 1313.

HAPALOPILUS NIDULANS (Fr.) Karst., Rev. Myc. 3:18. 1881.
Basidiocarps annual, sessile, resupinate to pileate, dimidiate; upper surface tomentose, becoming glabrous with age, reddish-brown (5YR 3/4); pore surface concolorous to golden (near 10YR 6/6), turning deep wine red in KOH, 3-5 pores per mm. **Hyphal system** monomitic; hyphae thin- to moderately thick-walled, frequently branched, nodose-septate, 3.5-5.5 µm diam. **Sterile hymenial elements** lacking. **Basidia** clavate, 4-sterigmate, with a basal clamp, 20-24 x 4-6 µm. **Basidiospores** ovoid to short ellipsoid, hyaline, smooth, negative in Melzer's reagent, 3-4 x 2.5-3 µm. **Voucher specimen** - JPL 1295.

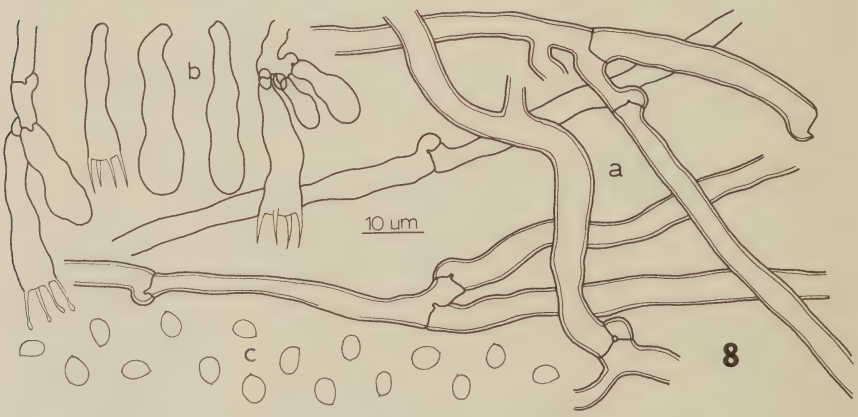

Fig. 8. **Hapalopilus nidulans.** (JPL 1295). a) subicular hyphae from context, some with slightly thick walls; b) basidia; c) basidiospores.

RADULOMYCES CONFLUENS (Fr.) M.P. Chris., Dansk Bot. Arkiv 19:2, p. 230. 1960.
Basidiocarps effused in small patches, smooth, adnate, pinkish-buff (near 7.5YR 7/4), crustaceous; subiculum sometimes visible through cracks in dried specimens, white, floccose; margin finely fimbriate under a 10X lens, white, sometimes abrupt. **Hyphal system** monomitic; subicular hyphae nodose-septate, thin-walled, 2-3 µm diam. **Sterile hymenial elements** lacking. **Basidia** clavate, 4-sterigmate, with conspicuous oily contents and a basal clamp, some sinuous and tapering to a very narrow base, 37-50 x 8.5-11 µm. **Basidiospores** hyaline, smooth, multiguttulate, negative in Melzer's reagent, varying from ovoid (6.5-7 x 5.5-6 µm) to ellipsoid-obovate, 8.5-11 x 6-7 µm. **Voucher specimen** - JPL 1301.

Fig. 9. **Radulomyces confluens** (JPL 1301). a) subicular hyphae; b) basidia; c) basidiospores.

HYPHODONTIA ARGUTA (Fr.) John Erikss., Symb. Bot. Upsal. 16:1, p. 104. 1958.
Basidiocarps widely effused, thin, dry, densely hydnaceous, the teeth conical to cylindric with fimbriate apices, cream colored (near 2.5Y 8/4); subiculum showing between the teeth, floccose, white; margin narrow, white, minutely fimbriate. **Hyphal system** monomitic; subicular hyphae slightly thick-walled, nodose-septate, frequently branched, 2-3.5 µm diam. **Cystidia** of two kinds; lagenocystidia with a thick-walled, tapered, encrusted apex, the base slightly thick-walled and swollen, with a basal clamp, 17.5-45 x 3-4.5 µm; thin-walled cystidia hyphoid, capitate, some flexuous, some with clamp connections, 26-38 x 3-4 µm. **Basidia** clavate, 4-sterigmate, with a median constriction, with a basal clamp, 13-27 x 3.5-4 µm. **Basidiospores** ovoid to ellipsoid, thin-walled, hyaline, smooth, negative in Melzer's reagent, 4-5 x 2.5-3.5 µm. **Voucher specimen** - JPL 1206.

INCRUSTOPORIA NIVEA (Jungh.) Ryv., Norw. J. Bot. 19:232. 1972.
Basidiocarps effused-resupinate to effused-reflexed; upper surface appressed-tomentose, becoming glabrous, turning dirty brown (near 7.5YR 5/4) with age; pore surface white to cream colored (near 2.5YR 9/4), discoloring brownish where touched; pores small, rounded to angular, glancing, 4-6 per mm. **Hyphal system** trimitic; generative hyphae nodose-septate, 2.5-5 µm diam, often heavily encrusted with fine crystals; skeletal hyphae hyaline, rarely branched, thick-walled, 3-6.5 µm diam, encrusted on dissepiment edges; binding hyphae small, irregularly branched to almost stellate, 1.5-2 µm diam. **Sterile hymenial elements** lacking. **Basidia** short-clavate, in small candelabrums, 4-sterigmate, with a basal clamp, 8-10 x 3-3.5 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, allantoid, very diffi-

cult to see under high magnification, 3.5-5 x 0.5-1 µm. **Voucher specimen** - JPL 1278.

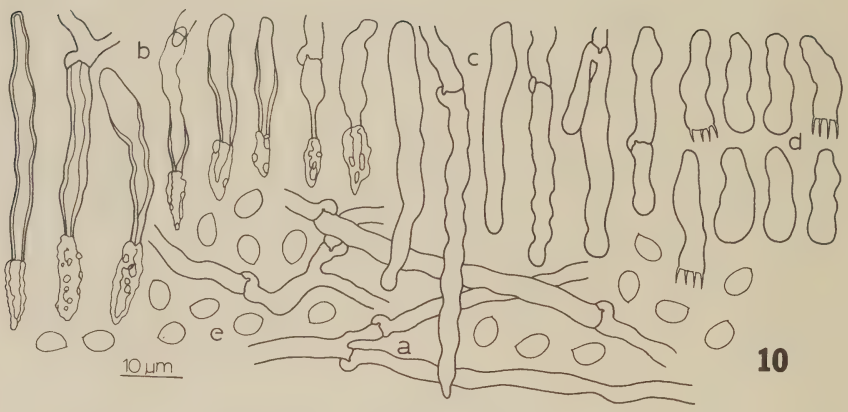

Fig. 10. **Hyphodontia arguta.** (JPL 1206). a) subicular hyphae; b) thick-walled, encrusted lagenocystidia; c) thin-walled, flexuous, capitate cystidia, some with clamp connections; d) basidia; e) basidiospores.

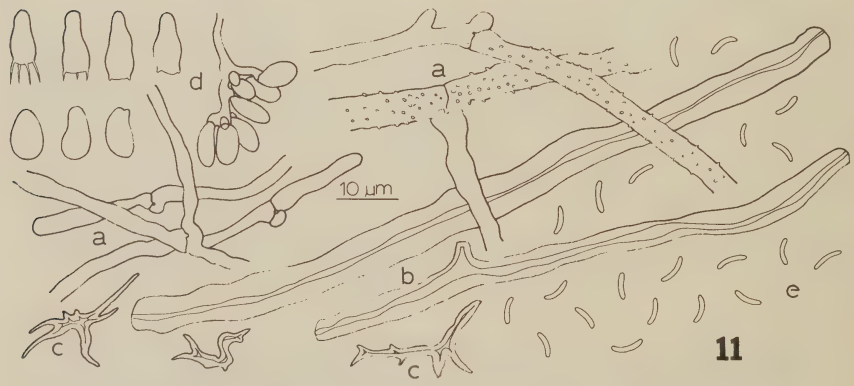

Fig. 11. **Incrustoporia nivea.** (JPL 1278). a) generative hyphae, some showing regular, fine encrustations; b) thick-walled skeletal hyphae; c) thick-walled binding hyphae; d) basidia, showing candelabrum; e) basidiospores.

OIDIUM CANDICANS (Sacc.) Linder., Lloydia 5:3. 1942.
Basidiocarps not seen. **Conidial state** grayish-yellow (near 5Y 8.5/4), floccose to mealy. **Conidiophores** thick-walled, apically branched, up to 150 µm long x 5-10 µm. **Conidia** lemon-shaped, light golden, 15-22 x 8.5-11 µm. **Voucher specimen** - JPL 1209.

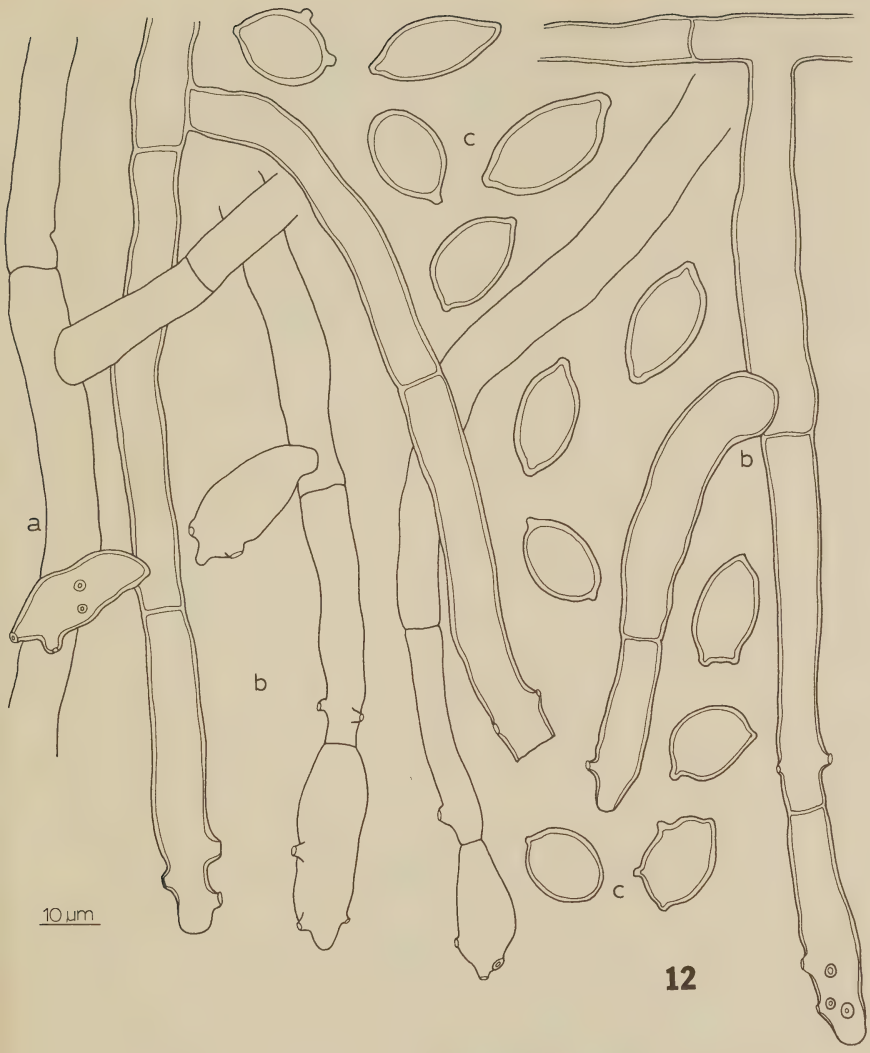

Fig. 12. **Oidium candicans.** (JPL 1209). a) subicular hypha; b) conidiophores; c) conidia.

PHANEROCHAETE ARIZONICA Burds. et Gilbn., Mycologia 66:785. 1974.
Basidiocarps effused in small patches, thin, with scattered aculei in the hymenial area, pinkish (near 7.5YR 8/4), cracking upon drying to reveal the white subiculum; margin thin to broad in some areas, white, separable, finely fimbriate. **Hyphal system** monomitic; subicular hyphae hyaline, thick-walled, simple-septate, 3.5-7 µm diam. **Cystidia** thin-walled, very slightly thick-walled at the base, cylindrical, with blunt apices, scattered, projecting up to 25 µm, 55-90 x 5-7 µm. **Basidia** slenderly clavate, 4-sterigmate, with a simple septum at the base, 24-36 x 3.5-4.5 µm. **Basidiospores** narrowly ellipsoid, hyaline, smooth, thin-walled, negative in Melzer's reagent, 4.5-5 x 2-2.5 µm. **Comments** - This fungus has not been reported previously from Colorado. It was described by Burdsall and Gilbertson (1974) as occurring on various Sonoran Desert hardwoods. **Voucher specimen** - JPL 1223.

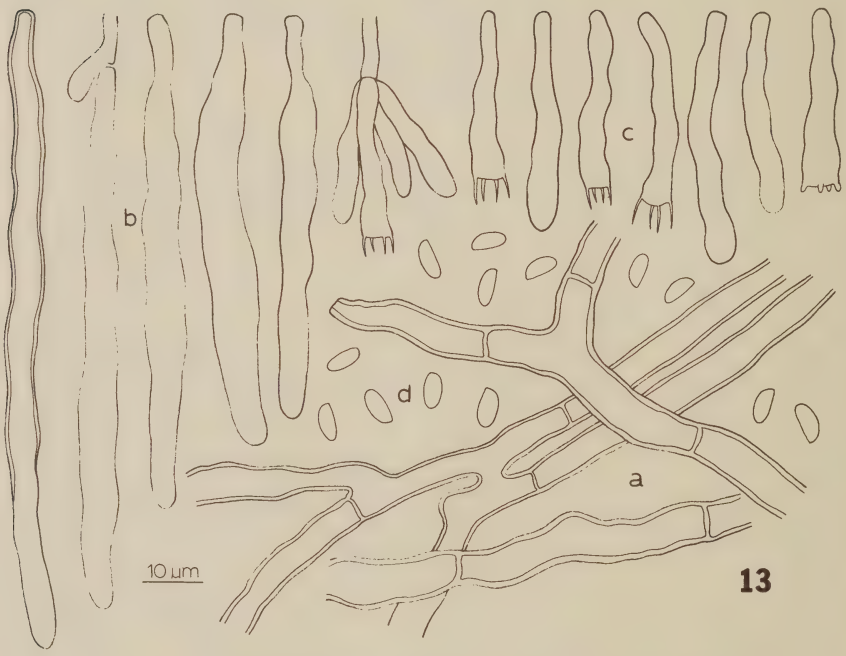

Fig. 13. **Phanerochaete arizonica.** (JPL 1223). a) thick-walled subicular hyphae; b) leptocystidia; c) basidia; d) basidiospores.

PHANEROCHAETE CARNOSA (Burt) Parm., Eesti NSV Tead. Akad. Toim. Biol. 16(4):388. 1967.
Basidiocarps widely effused-resupinate, smooth to slightly tuberculate, thick-felty, bright orangish-yellow when fresh, fading to dull yellow (near 2.5Y 9/4) to cream colored upon drying, often with orange highlights (near 7.5 YR 6/14); margin narrow, white, fimbriate, with occasional rhizomorphs. **Hyphal system** monomitic; subicular hyphae simple-

septate, thin-walled near hymenium, becoming very thick-walled near substratum, 3.5-6.5 µm diam. **Cystidia** thick-walled at base, becoming thin-walled toward the tapered apex, with a simple septum at the base, 63-78 x 4.5-6.5 µm. **Basidia** slender cylindric-clavate, 4-sterigmate, with a simple septum at the base, 28-38 x 4.5-6 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, ellipsoid to short-cylindric, 4-5(-6) x 2.5-3 µm. **Voucher specimen** - JPL 1200.

Fig. 14. **Phanerochaete carnosa.** (JPL 1200). a) thin- and thick-walled subicular hyphae; b) leptocystidia; c) basidia, showing typical loose candelabrum; d) basidiospores.

PHLEBIA LILASCENS (Bourd.) Erikss. et Hjortst., in John Erikss. et al., Cort. North Europe 6:1123. 1981.

Basidiocarps occurring on bark, effused, crustaceous, smooth to slightly phlebioid, cracking along folds upon drying, pinkish-buff to pinkish-gray (near 10YR 8/4 to 10YR 8/1); margin white, fimbriate, with pinkish to white rhizomorphs, these also present below the bark. **Hyphal system** monomitic; subicular hyphae thin-walled, nodose-septate, 2.5-6 µm. **Sterile hymenial elements** lacking. **Basidia** slender clavate, 4-sterigmate, with a basal clamp, 23-25 x 4-5 µm. **Basidiospores** short-cylindric to ellipsoid, hyaline, smooth, negative in Melzer's reagent, 4-5 x 2-2.5 µm. **Comments** - This fungus has been collected only once in this study. The hymenial surface of this specimen shows a slightly phlebioid configuration; the margin is fimbriate and sturdy white rhizomorphs are present. Eriksson et al. (1981) do not mention rhizomorphs and indicate the margin to be indeterminate. Christiansen (1960) briefly describes a fungus he refers to **Phlebia lacteola,**

(Bourd.)M.P. Chris., another possible name for this fungus, but he indicates the presence of leptocystidia and does not clarify the presence of clamp connections. His macroscopic description agrees better with my collection than does that of Eriksson et al. for **P. lilascens**, however. Eriksson et al. (1981) consider recent Danish specimens determined as **P. lacteola** to be **P. lilascens. Voucher specimen** - JPL 1312.

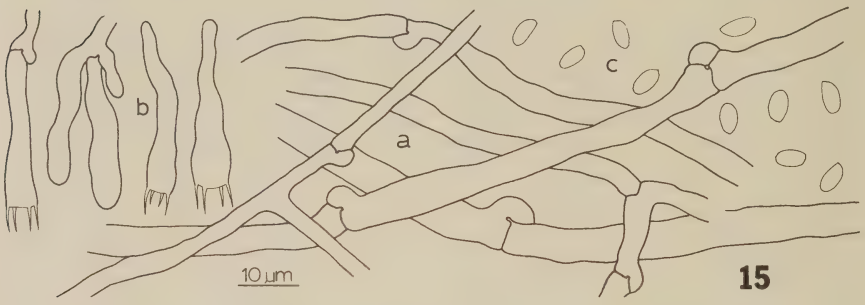

Fig. 15. **Phlebia lilascens.** (JPL 1312). a) subicular hyphae; b) basidia; c) basidiospores.

PYCNOPORUS CINNABARINUS (Jacq.:Fr.) Karst., Krit. Finl. Basidsv., p. 308. 1889.
Basidiocarps annual, reflexed to sessile (sometimes completely resupinate when developing along the underside of a surface), dimidiate to elongated; pileus surface glabrous, light orange at first but aging to pale orange or dirty white; pore surface bright orange (1.25YR 6/12 to 1.25YR 6/14), the pores angular, 3-4 per mm; context lighter than the pores, soft, losing color in KOH. **Hyphal system** trimitic; generative hyphae thin-walled, nodose-septate, 1.5-3.5 µm diam; skeletal hyphae thick-walled, aseptate rarely branched, 3.5-6 µm diam; binding hyphae thick-walled, richly but loosely branched, conspicuous, generally of smaller diameter than the skeletals, 3-4.5 µm diam. **Sterile hymenial elements** lacking. **Basidia** clavate, 4-sterigmate, with a basal clamp, 11-18 x 5-6 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, short-cylindric, 4-5.5 x 2-3 µm. **Voucher specimen** - JPL 1162.

RESUPINATUS APPLICATUS (Batsch: Fr. sensu Kauffman) S.F. Gray, Nat. Arr. Brit. Plants 1:617. 1821.
Basidiocarps small, 1-3 mm diam, sessile, laterally attached or dorsally attached, with margins often attached also; pileus dark grayish-blue to blackish, finely tomentose, often striate at the margins; margin inrolled; lamellae lighter than pileus, brownish, with light brown edges; context duplex, with the lower layer composed of gelatinizing hyphae, the two layers less than 1 mm thick. **Hyphal system** monomitic; hyphae nodose-septate; upper context hyphae pigmented, with normal clamps; lower contextual hyphae hyaline, contorted, often with distorted clamps. **Pleurocystidia** lacking. **Cheilocystidia** with a single attenuated tip or dendritically branched, with a basal clamp, 18-30 x 3.5-4.5 µm. **Basidia** clavate, 4-sterigmate, with a basal clamp, 23-32 x 5-7 µm. **Basidiospores** hyaline, smooth, negative in Melzer's reagent, globose to subglobose, with a prominent apiculus, 3-4 x 4-5 µm. **Voucher specimen** - JPL 1277.

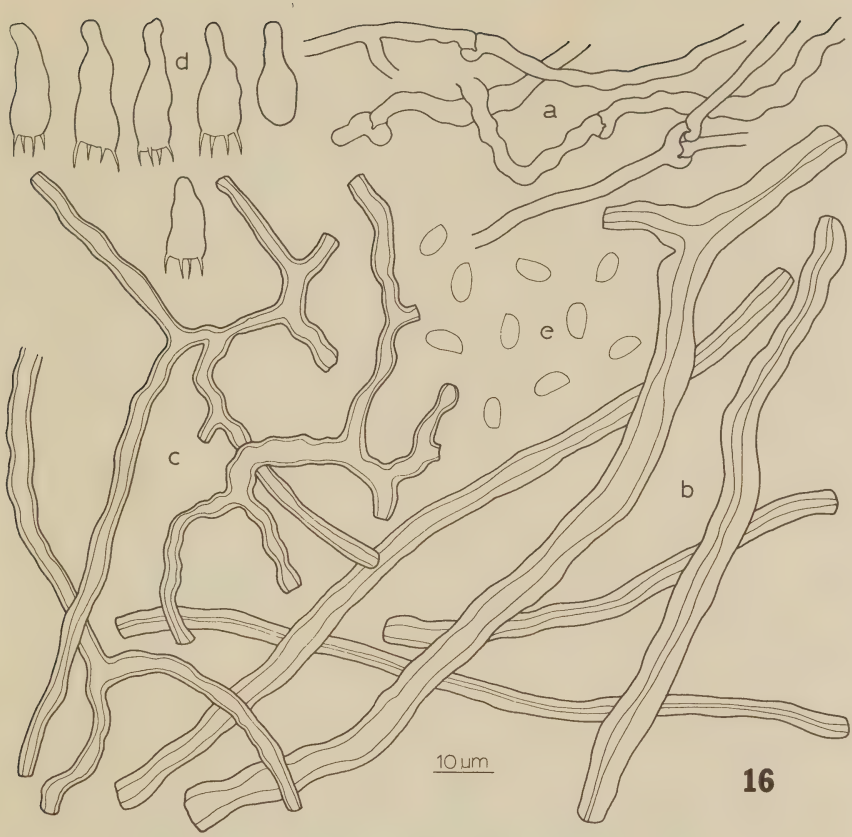

Fig. 16. **Pycnoporus cinnabarinus.** (JPL 1171). a) generative hyphae; b) thick-walled skeletal hyphae; c) thick-walled, branched binding hyphae; d) basidia; e) basidiospores.

STEREUM HIRSUTUM (Willd.:Fr.) S.F. Gray, Nat. Arr. Brit. Plants 1:653. 1821.

Basidiocarps annual, effused-reflexed; pileus matted-tomentose, golden brown (10YR 5/6 to 10YR 4/8), indistinctly zonate; hymenial surface smooth, cracking somewhat irregularly upon drying to expose a whitish subiculum; hymenial surface pinkish-gray (near 10YR 7/2 to 10YR 7/4). **Hyphal system** dimitic; generative hyphae hyaline, simple-septate, 1.5-3 µm diam; skeletal hyphae hyaline, aseptate, 3.5-7 µm diam; hyphae from pileus surface similar to skeletals but more branched and lightly pigmented, 3-5 µm diam. **Pseudocystidia** cylindric, thick-walled, slightly broader at apex with a single apical papilla, with a simple septum at the base, 63-84 x 5.5-7 µm. **Basidia** slender, cylindric-clavate, 4-sterigmate, with a simple septum at the base, 21-25 x 3.5-4.5 µm. **Basidiospores** hyaline, smooth, amyloid in Melzer's

Fig. 17. **Resupinatus applicatus.** (JPL 1277). a) gelatinized, hyaline, subicular hyphae from lower context; b) lightly pigmented hyphae from upper context; c) cheilocystidia; d) basidia; e) basidiospores.

TOMENTELLA PILOSA (Burt) Bourd. et Galz., Bull. Soc. Mycol. France 40:151. 1924.
Basidiocarps byssoid, separable, gray-brown (10YR 5/2 to 7.5YR 5/2 to 7.5YR 4/2); fertile surface smooth to colliculose; margin concolorous, indistinct to abrupt; cordons barely apparent with a 10X lens. **Hyphal system** monomitic; subicular hyphae golden in color, nodose-septate, frequently branched, 3-5 µm diam; cordons scattered, golden, nodose-septate, 7.5-11 µm diam. **Cystidia** broadly capitate, golden, arising directly from subicular hyphae, with a basal clamp subtending the capitate apical cell, but with simple septa and clamps on other cells along the length of the cystidium, the apical cell 37-49 x 10-14 µm. **Basidia** stout, clavate, 4-sterigmate, with oily inclusions, with a basal clamp, 47-56 x 9-11 µm; sterigmata 4-7 µm long. **Basidiospores** irregular, echinulate, with golden-brown pigment, negative in Melzer's reagent, 6-9 x 9-10(-13) µm. **Voucher specimen** - JPL 1294.

TRECHISPORA VAGA (Fr.) Liberta, Taxon 15:319. 1966.
Basidiocarps resupinate, adnate, separable, felty, with abundant cordons over the hymenial surface, buff to drab yellow-brown (10YR 8/4 to 2.5Y 8/4 to 2.5Y 8.5/2); margin fimbriate, with scattered rhizomorphs, white. **Hyphal system** monomitic; subicular hyphae thin-walled, nodose-septate, some with ampullate septa, 1.5-5 µm diam; fiber hyphae present in abundance, aseptate, occurring in rope-like bundles, thick-walled, 1-1.5 µm diam. **Sterile hymenial elements** lacking. **Basidia** clavate, 4-sterigmate, with a basal clamp, 17-19 x 5.5-6 µm. **Basidiospores** hyaline, echinulate, negative in Melzer's reagent, obovate to ellipsoid, with a flattened adaxial face, 4.5-5 x 3-3.5 µm. **Voucher specimen** - JPL 1207.

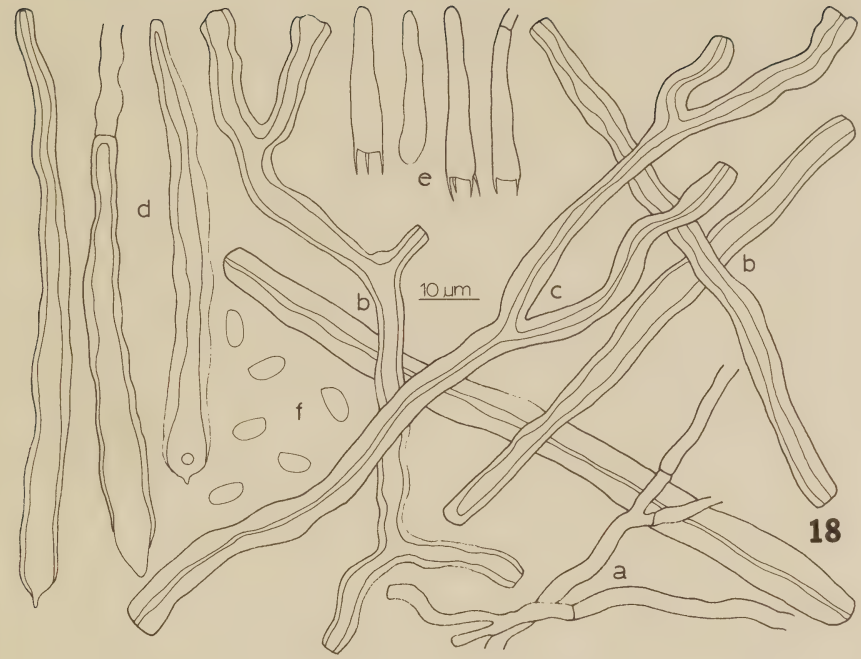

Fig. 18. **Stereum hirsutum.** (JPL 1291). a) hyaline generative hyphae; b) hyaline thick-walled skeletal hyphae; c) lightly pigmented skeletal hypha from pileus tomentum; d) pseudocystidia; e) basidia; f) basidiospores.

Discussion

Gloeophyllum trabeum is the first brown-rot fungus to be reported on Gambel oak in this series. White rot fungi still far outnumber brown rot fungi on this substratum. Shope (1931) reports **G. trabeum** on "coniferous and deciduous hosts," but does not specifically mention oak. He refers to it as "uncommon."

Oidium candicans is the anamorph of **Botryobasidium candicans** John Erikss. The teleomorph has not yet been collected on Gambel oak.

Phanerochaete arizonica is reported for the first time from Colorado. This collection extends its known range about 800 km north of the holotype collection.

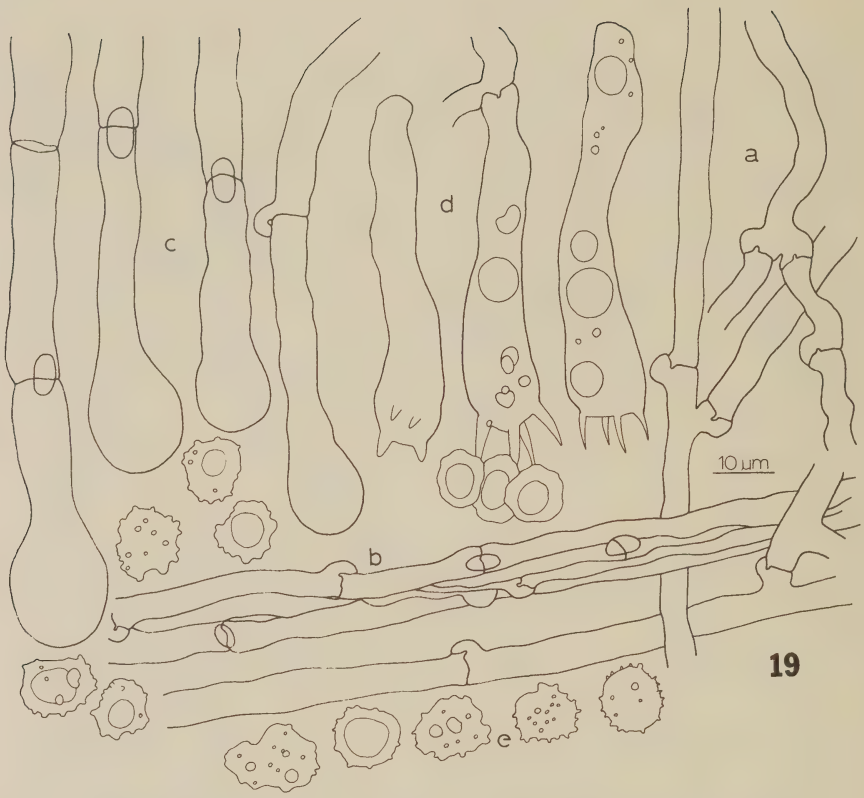

Fig. 19. **Tomentella pilosa.** (JPL 1294). a) subicular hyphae; b) pigmented cordon; c) cystidia with simple and clamped septa; d) basidia; e) pigmented basidiospores.

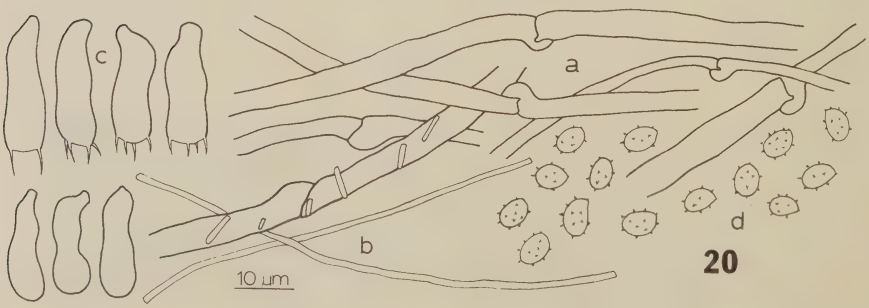

Fig. 20. **Trechispora vaga.** (JPL 1207). a) subicular hyphae; b) fiber hyphae; c) basidia; d) basidiospores.

Acknowledgments

Thanks are extended to Mrs. Donna Giersch for typing and for helpful editorial suggestions. Thanks are due also to Dr. R.L. Gilbertson, who critically read the manuscript and gave assistance on identifications.

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MYCOTAXON

Vol. XXV, No. 1, pp. 85-93 January-March 1986

NEW SPECIES IN THE LICHEN FAMILY PARMELIACEAE (ASCOMYCOTINA)

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Abstract.--The following 12 new species in the lichen family Parmeliaceae are described: Bulbothrix australiensis Hale, B. lopezii Hale, B. oliveirai Fletcher, Hypotrachyna meridensis Hale, Parmotrema betaniae Hale, P. catarinae Hale, P. fumarprotocetraricum Marcelli & Hale, P. lobulatum Marcelli & Hale, P. madilynae Fletcher, P. schindleri Hale, P. sorediiferum Hale and P. virescens Hale.

Bulbothrix australiensis Hale, sp. nov. Fig. 1

Thallus corticola, arcte adnatus, rigidulus, albido-cinerascens, 2-3 cm diametro, lobis sublinearibus, contiguis, 0.8-2 mm latis, margine bulbato-ciliatis, ciliis magnis, conspicue inflatis, superne planus, nitidus, continuus, dense isidiatus, isidiis cylindricis, simplicibus vel sparse ramosis, 0.1-0.15 mm diametro, usque ad 1 mm altis, cortice superiori 12-15 µm crasso, strato gonidiale 15-25 µm crasso, medulla alba, 80-90 um crassa, cortice inferiori 12-15 µm crasso, subtus planus, castaneus, modice rhizinosus, rhizinis castaneis, simplicibus. Pycnidia immersa, 110-130 µm diametro, conidiis cylindricis, 1 X 5-6 µm. Apothecia rara, adnata, ca 1 mm diametro, sporis evolutis.

Chemistry: Atranorin, salazinic acid.

Holotype: Observation Point, Ku-Rin-Gai National Park, New South Wales, Australia, M. E. Hale 59360, 20 Jan. 1982 (US; isotype in MEL).

This new species has large bulbate cilia, narrow lobes and robust cylindrical isidia. It has been collected so far only in the Ku-Rin-Gai area on roadside Casuarina. Another Australian endemic, also in coastal New South Wales, P. (Bulbothrix) subtabacina Elix, has a distinctly maculate upper surface, slender bulbate cilia and a black lower surface. While pantropical B. isidiza (Nyl.) Hale has a brown lower surface, the lobes are broader (3-5 mm wide) and weakly white maculate.

Bulbothrix lopezii Hale, sp. nov. Fig. 2

Thallus corticola, arcte adpressus, fragilissimus, pallide albido-cinerascens, 3-5 cm latus, lobis sublinearibus, contiguis vel imbricatis, dichotome ramosis, 1-3 mm latis, margine conspicue bulbato-ciliatis, superne nitidus, planus, continuus vel leviter albo-maculatus, dense lobulatus, lobulis dorsiventralibus, dichotome divisis, margine bulbato-ciliatis, 0.2 mm latis, usque ad 1 mm longis, cortice superiori 10-12 µm crasso, strato gonidiale 10 µm crasso,

medulla alba, 30-35 µm crassa, cortice inferiori 9-10 µm crasso, subtus planus, niger, nitidus, modice rhizinosus, rhizinis pallido-castaneus, dense ramosis. Pycnidia non visa. Apothecia adnata, 0.5-1 mm diametro, disco pallido, amphithecio ecoronato; hymenium 60 µm altum; sporae male evolutae, 3 X 6 µm.

Chemistry: Atranorin, traces of unidentified substances (fatty acids?) or nothing present.

Holotype: Near El Carrizal, Sierra Nevada de Mérida, Estado Mérida, Venezuela, elev. 1400 m., M. López and M. E. Hale 20087 (MERF; isotype in US).

Specimens examined. Venezuela: Same locality as the holotype, López and Hale 20103, 20141, 20349 (US).

This species is unique in having dense, procumbent, dorsiventral lobules and lacking distinctive chemistry. The only possible relative is B. viridescens (Lynge) Hale, a rare species in southern Brazil and Uruguay which has coronate apothecia and lacks lobules. Bulbothrix lopezii is known only from the type locality.

Bulbothrix oliveirai Fletcher, sp. nov. Fig. 3

Thallus corticola, arcte adnatus, fragilis, albo-cinereus, 2-3 cm latus, lobis sublinearibus, contiguis, dichotome divisis, 0.6-1.2 mm latis, margine aetate sublobulatis, bulbato-ciliatis, ciliis apice dense ramosis, superne planus, nitidus, apicem loborum versus pustulatus, pustulis erosis, subsorediatis, cortice superiori 14-16 µm crasso, strato gonidiale ca 15 µm crasso, medulla alba, 60-70 µm crassa, cortice inferiori 12-14 µm crasso, subtus niger, dense rhizinosus, rhizinis dichotome ramosis. Pycnidia et apothecia non visa.

Chemistry: Atranorin and gyrophoric acid.

Holotype: Base aerea de Cachimbo, 20 km N of border with Mato Grosso on Cuiaba-Santarem highway, Pará, Brazil, elev. 480 m, L. Brako and M. J. Dibben 5804, 25 April 1983 (NY; isotype in US).

Specimens examined. Brazil: Pará, Brako and Dibben 6012, 6716, 6861 (NY, US); São Paulo, Fletcher 10031 (US).

This species is unusual in having subapical, eroded pustules. The floor of the pustular areas where the medulla is exposed turns black, and rather sparse coarse soredia form around the rim. It is common in forests in the sandstone areas in the state of Pará but also occurs near sea level in São Paulo. The only other pustulate species in the genus, the African B. pustulata (Hale) Hale, is broader lobed with extensive laminal pustules and salazinic acid.

Hypotrachyna meridensis Hale, sp. nov. Fig. 4

Thallus saxicola, laxe adnatus, rigidulus, albido-cinerascens, 5-8 cm latus, lobis sublinearibus, dichotome lobatis, subimbricatis, margine integris, 1.5-3 mm latis, superne nitidus, continuus, planus, modice isidiatus, isidiis cylindricis, 0.06-0.09 mm diametro, usque ad 1.5 mm altis, simplicibus vel ramosis, cortice superiori 12-15 µm crasso, strato gonidiale 15-20 µm crasso, medulla alba, 80-100 µm crassa, cortice inferiori 15-16 µm crasso, subtus planus, niger, modice vel dense rhizinosus, rhizinis dichotome ramosis. Pycnidia non visa. Apothecia adnata, 2-7 mm diametro, amphithecio isidiato; hymenium 45-50 µm altum; sporae male evolutae, 5 X 6-8 µm.

Chemistry: Atranorin, alectoronic acid and α-collatolic acid.

Holotype: On rock along forested trail above fish hatchery, Mucuy, Estado Mérida, Venezuela, elev. 2300 m, M. E. Hale 43030, 4 Feb. 1974 (US; isotype in MERF).

Specimens examined. Guatemala: Baja Vera Paz, Hale 38331 (US). Panama: Chiriquí, Hale 46107, 46111, Scholander s.n. (US). Venezuela: Mérida, Hale 42928 (US).

Hypotrachyna meridensis appears to be or at least approximates the isidiate morphotype of H. protenta Hale. Both species are saxicolous, occurring on open outcrops in pastures at 1500-3400 m elevation. The only other isidiate, alectoronic acid-containing Hypotrachyna is H. ensifolia (Kurok.) Hale, a more fragile, corticolous or terricolous lichen with cylindrical, procumbent isidia.

Parmotrema betaniae Hale, sp. nov. Fig. 5

Thallus corticola, laxe adnatus, membraneus, pallide stramineo-albicans, usque ad 14 cm diametro, lobis ambitu rotundatis, 8-12 mm latis, eciliatis, superne continuus, aetate rugosus, isidiis sorediisque destitutus, cortice superiori 10-12 µm crasso, strato gonidiale ca 20 µm crasso, medulla superne alba, subtus flavicans vel pallide aurantiaco-salmonea, 150-200 µm crassa, cortice inferiori 15 µm crasso, subtus planus, niger, centrum versus dense rhizinosus, ambitu nudus, castaneus. Pycnidia numerosa, immersa, 130-150 µm diametro, conidiis sublageniformibus, 1 X 5-6 µm. Apothecia numerosa, subpedicellata, urceolata, 3-6 mm diametro, disco imperforato, amphithecio crenato; hymenium 75-80 µm altum; sporae 11-12 X 22-24 µm, episporio 1-1.5 µm crasso.

Chemistry: Atranorin, protocetraric acid, entothein and unidentified pigments.

Holotype: Via Villa Paez-Betania, valley of Paramó de Tamá, Estado Táchira, Venezuela, elev. 2300 m, M. E. Hale 45106, 25 March 1975 (US; isotype in MERF).

This unique species has very conspicuous medullary pigmentation, most of the medulla, except for the upper part, being pale orange or salmon red to yellow. It is known only from the type collection.

Parmotrema catarinae Hale, sp. nov. Fig. 6

Thallus corticola, laxe adnatus, rigidulus, albido- vel pallide stramineo-cinereus, 6-12 cm latus, lobis rotundatis, subadscendentibus, margine late dissectis, 6-10 mm latis, margine crebre ciliatis, ciliis 2-4 mm longis, superne nitidus, planus, albo-maculatus, sorediis isidiisque destitutus, cortice superiori 18-20 µm crasso, strato gonidiale ca 15 µm crasso, medulla alba, 90-110 µm crassa, cortice inferiori 16-18 µm crasso, subtus centrum versus niger, sparse rhizinosus, ambitu nutus, albus vel albo-variegatus. Pycnidia numerosa, 90-120 µm diametro, conidiis cylindricis, 0.5 X 5-7 µm. Apothecia substipitata, 8-15 mm diametro, margine lobulato-dissecta, ciliata, amphithecio valde albo-maculato, disco castaneo, plano, imperforato; hymenium 130-150 µm altum; sporae 14-16 X 24-28 µm, episporio 2 µm crasso.

Chemistry: Atranorin and gyrophoric acid.

Holotype: Santa Cecilia, Santa Catarina, Brazil, Reitz & Klein 12975 9 July 1962 (US).

Specimens examined. Brazil: Santa Catarina, Reitz & Klein 15901 (US); São Paulo, Kalb & Plöbst 79 (Kalb herb.).

This conspicuous species appears to be a chemotype of the well-known P. melanothrix (Mont.) Hale, which contains protolichesterinic acid and has a broader range, from Santa Catarina north to Paraná and Minas Gerais in Brazil.

Parmotrema fumarprotocetraricum Marcelli and Hale, sp. nov. Fig. 7

Thallus corticola, adnatus vel laxe adnatus, subrigidus, pallide stramineo-albicans, 8-12 cm latus, lobis rotundatis, 8-15 mm latis, margine sparse ciliatis, ciliis 0.5-1 mm longis, superne nitidus, albo-maculatus, aetate irregulariter reticulato-fissus, modice isidiatus, isidiis congestis, 0.06-0.09 mm diametro, usque ad 0.4 mm altis, cylindricis vel pro parte granulatis, cortice superiori 15-18 µm crasso, strato gonidiale ca 20 µm crasso, medulla alba, 130-160 µm crassa, cortice inferiori 9-10 µm crasso, subtus omnino castaneus, dense rhizinosus, rhizinis brevibus, ambitu papillatus. Pycnidia nec apothecia visa.

Chemistry: Atranorin, fumarprotocetraric and protocetraric acids.

Holotype: On mangrove trees near bridge over Itanhaem River, km 112 of the BR-101 hwy, Itanhaem, São Paulo, Brazil, Marcelo Pinto Marcelli 8 (US).

Specimens examined. Brazil: Bahía, Blanchet in 1867 (G); São Paulo, same locality as holotype, Marcelli 4, 7 (US); Santa Catarina, Reitz & Klein 13322a (US).

Fumarprotocetraric acid is rare in Parmotrema. Out of about 228 species in this genus, only this one and two sorediate Old World species, P. pardii (Krog & Swins.) Krog & Swins. and P. pseudograyanum (Hale) Hale, contain it. Morphologically P. fumarprotocetraricum is very close to P. subtinctorium (Zahlbr.) Hale and related species, P. recipiendum (Nyl.) Hale, P. subsumptum (Nyl.) Hale, etc., which have salazinic acid or norlobaridone. The three localities for this species are widely separated in Brazil, ranging from mangrove in São Paulo to forests at 800 m in Santa Catarina.

Parmotrema lobulatum Marcelli and Hale, sp. nov. Fig. 8

Thallus corticola, fragilis, albo-cinereus, 5-7 cm latus, lobis subirregularibus, apice rotundatis, congestis, 3-6 mm latis, margine lobulatis, lobulis sublinearibus, 0.2-0.4 mm longis, sparse ciliatis, ciliis 0.5-1.5 mm longis, superne planus, continuus, crasse isidiato-lobulatus, lobulis procumbentibus, cortice superiori 9-10 µm crasso, strato gonidiale ca 15 µm crasso, medulla alba, 60-70 µm crassa, cortice inferiori 10-12 µm crasso, subtus centrum versus niger, sparse rhizinatus, ambitu nudus, castaneus. Pycnidia numerosa, ca 100 µm diametro, conidiis cylindricis, 0.7 X 7-9 µm. Apothecia non visa.

Chemistry: Atranorin, stictic acid and constictic acid.

Holotype: On mangrove trees near Guaratuba River, Bertioga, São Paulo, Brazil, Marcelo Pinto Marcelli 38 (US).

This mangrove species is apparently related to P. crinitum (Ach.) Choisy but there are no isidia, only small procumbent lobules. It is known only from the type locality.

Parmotrema madilynae Fletcher, sp. nov. Fig. 9

Thallus corticola, adnatus vel laxe adnatus, mollis, albido- vel stramineo-cinereus, 6-10 cm latus, lobis rotundatis, 4-7 mm latis, margine sparse vel modice ciliatis, ciliis 0.5-2 mm longis, superne planus vel valde rugosus, opacus, reticulato-fissus, submargine pustulatus, diffuso-sorediatus, cortice superiori ca 15 µm crasso, strato gonidiale ca 15 µm crasso, medulla alba, 90-110 µm crassa, cortice inferiori 13-16 µm crasso, subtus niger, modice rhizinosus, ambitu anguste nudus, castaneus. Pycnidia numerosa, conidiis non visis. Apothecia rara (ex Marcelli 6) substipitata, 3-6 mm diametro, amphithecio rugoso, sorediato, eciliato, disco castaneo, imperforato; hymenium 95-100 µm altum; sporae 14-15 X 23-25 µm, episporio 2 µm crasso.

Chemistry: Atranorin and protocetraric acid.

Holotype: Ilha Comprida, 4 km SSE of Cananeia, São Paulo, Brazil, elev. s.l., G. Eiten and W. D. Clayton 6132-b, 16 Feb. 1965 (US).

Specimens examined. Brazil: São Paulo, Eiten and Clayton 6133, Fletcher 10210, Marcelli 5, 6 (US).

Another member of the P. gardneri (Dodge) Serus. group, P. madilynae has extensive sorediate pustules in a broad submarginal zone. A related species in the Pacific area, P. setchellii (Vain.) Hale, also has a rugose-pustulate surface but soredia are poorly developed and the thallus is more coriaceous. Parmotrema madilynae occurs at low elevations in São Paulo.

Parmotrema schindleri Hale, sp. nov. Fig. 10

Thallus saxicola, membraneus, cinereo-albus, 6-8 cm latus, lobis ambitu rotundatis, 4-7 mm latis, aetate sparse laciniatis, axillis loborum ciliatis, ciliis sparsis, 0.5-1 mm longis, margine et submargine sorediatis, soraliis crassis, fere subfatiscentibus, superne planus, opacus, continuus, demum rugulosus, cortice superiori 14-16 µm crasso, strato gonidiale ca 15 µm crasso, medulla alba, 60-90 µm crassa, cortice inferiori 9-11 µm crasso, subtus niger, sparse rhizinosus, ambitu nudus, pallide castaneus. Pycnidia nec apothecia visa.

Chemistry: Atranorin, protocetraric acid and gyrophoric acid.

Holotype: An Sandsteinfelsen in Vila Velha, Curitiba, Est. Paraná, Brazil, elev. 800 m, H. Schindler 4666a, 27 Aug. 1973 (US).

Specimens examined. Brazil: Paraná, same locality as the holotype, Schindler 4666, 4667 (US).

This Brazilian species is also in the protocetraric acid-containing P. gardneri complex. It is differentiated by the coarse, subfatiscent soralia produced mostly on secondary laciniae and by the co-occurrence of gyrophoric acid. It also seems to be strictly saxicolous. Only one other species, the African P. umbrosum (Krog & Swins.) Krog & Swins., has these two acids, but the soralia are powdery and marginal.

Parmotrema sorediiferum Hale, sp. nov. Fig. 11

Thallus saxicola, laxe adnatus, membraneus, stramineo- vel albido-cinereus, 12-18 cm latus, lobis rotundatis, 10-18 mm latis, modice ciliatis, ciliis 2-4 mm longis, simplicibus vel furcatis, superne planus, nitidus, continuus, cortice ad marginem fissurino, pustulascenti, aetate crasse sorediato, lobis sorediatis plus minusve subrevolutis, cortice superiori 16-18 µm crasso, strato gonidiale ca 20 µm crasso, medulla alba, 110-130 µm crassa, cortice inferiori 18-20 µm crasso, subtus niger, nitidus, modice rhizinosus, ambitu nudus, castaneus vel anguste albo-variegatus. Pycnidia non visa. Apothecia bene evoluta, substipitata, suborceolata, 3-15 mm diametro, amphithecio diffuso-sorediato, eciliato, disco castaneo, imperforato. hymenium 85-90 µm altum; sporae 12-15 X 22-24 µm, episporio 1.5 µm crasso.

Chemistry: Atranorin, alectoronic acid and α-collatolic acid.

Holotype: Open rocky pasture, Via Villa Paez-Betania, valley of Paramó de Tamá, elev. 2300 m, Estado Táchira, Venezuela, M. Hale and M. López 45164, 25 March 1975 (US; isotype in MERF).

This conspicuous species is closest to P. mellissii (Dodge) Hale, which has submarginal isidia or sorediate isidia, sometimes becoming quite dense. Parmotrema sorediiferum initially has marginal soralia but soon develops a broad submarginal zone of soralia and open sorediate pustules which form dense masses. The cortex is rather fragile and flakes off in places. The cilia are much longer than in P. mellissii. The species is known only from the type locality.

Parmotrema virescens Hale, sp. nov. Fig. 12

Thallus corticola, laxe adnatus, pallide viridi-flavicans, 8-15 cm latus, lobis ambitu rotundatis, 5-10 mm latis, axillis ciliatis, ciliis 1.1.5 mm longis, margine sorediatis, soraliis linearibus, plus minusve subrevolutis aetate, superne opacus, continuus vel tenuiter reticulato-fissus, cortice superiori 13-15 µm crasso, strato gonidiale 15-20 µm crasso, medulla alba, 90-130 µm crassa, cortice inferiori 15-18 µm crasso, subtus planus, niger, centrum versus sparse vel modice rhizinosus, margine nudus, castaneus, laciniis secundariis albo-variegatis. Pycnidia non visa. Apothecia rara (ex Hale 45134a), stipitata, urceolata, ca 2 mm diametro, amphithecio sorediato, eciliato, disco imperforato; hymenium 60 µm altum; sporae non evolutae.

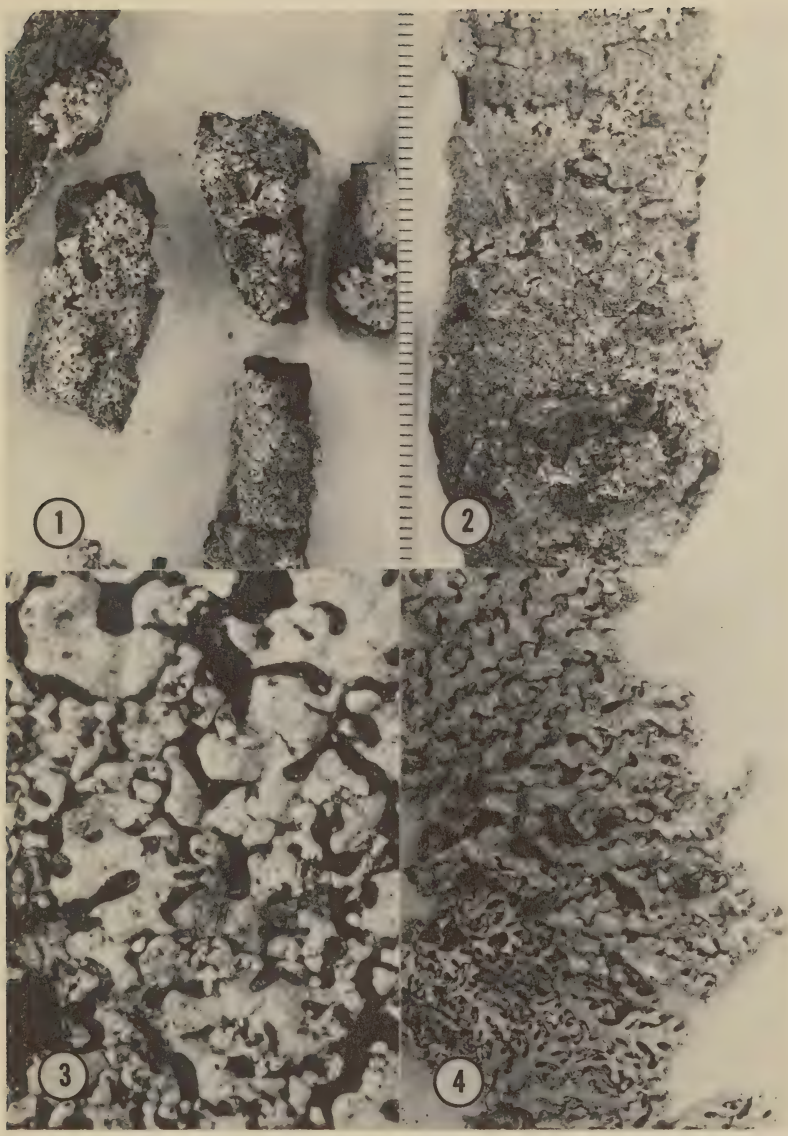
Chemistry: Usnic acid, atranorin, protocetraric acid.

Holotype: El Cobre Chiquito, Paramó de Tamá, Estado Táchira, Venezuela, elev. 2700 m, M. E. Hale and M. López 45557, 28 March 1975 (US; isotype in MERF).

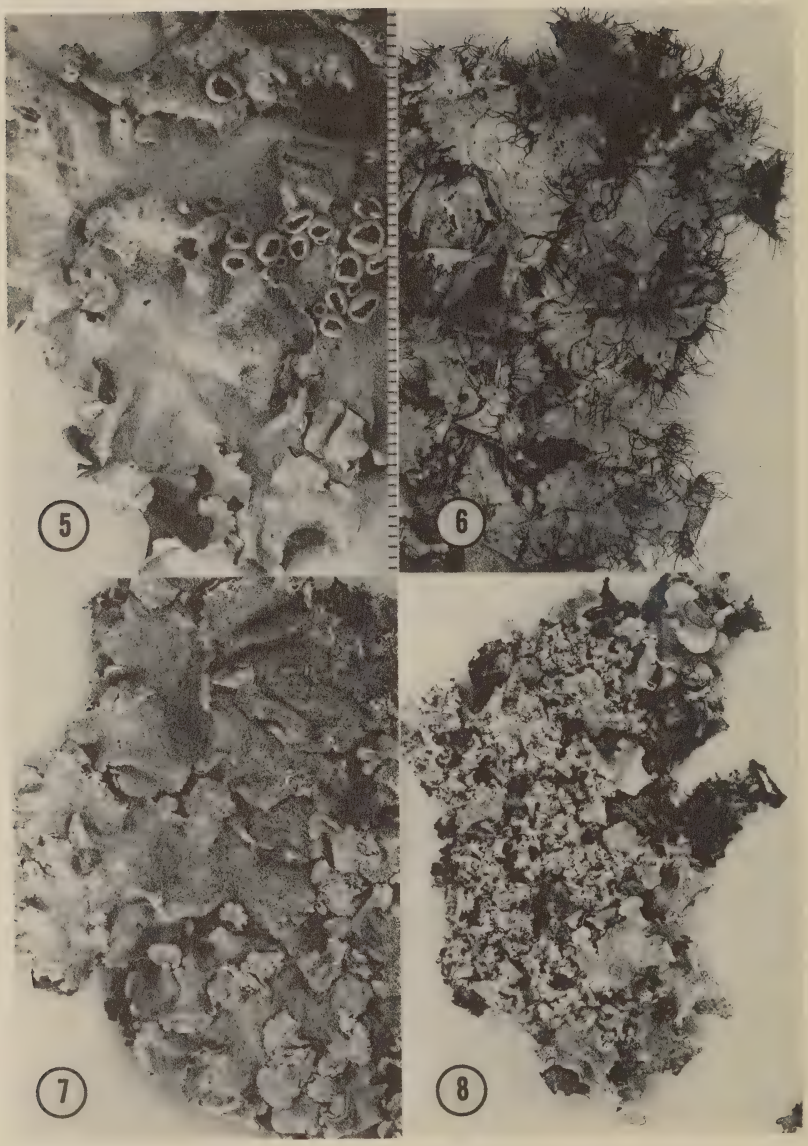
Specimens examined. Ecuador: Azuay, Arvidsson and Nilson 1111 (GB, US). Venezuela: Merida, López and Hale 20302, 20307, 20335, Hale and López 42016a, 42017, 42026, 42028, 42104, 42383, 42650, 42691, 42693, 42830, 43243, 45216, 45134a, 45280, 45547 (MERF, US).

This species belongs to the ill-defined protocetraric acid-containing group. The closest usnic acid-deficient species would be widespread P. gardneri. Closely related P. dilatatum (Vain.) Hale also contains echinocarpic acid and often traces of usnic acid, although the thallus is never as distinctly yellow as in P. virescens. Two other usnic acid-containing species lack cilia: P. apricum (Krog & Swins.) Krog & Swins. from Africa and P. dominicanum (Vain.) Hale from the West Indies. Parmotrema virescens seems to be restricted to the Andes at an elevation of 2400 to 3500 m.

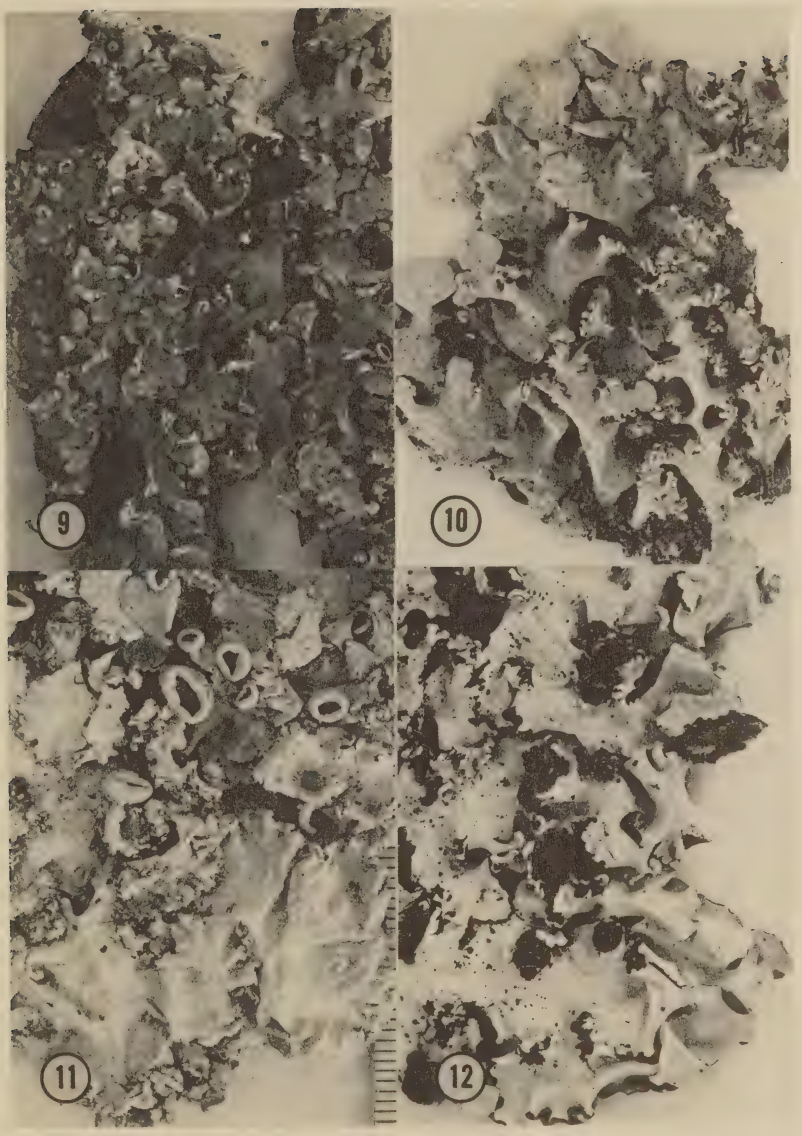
I wish to thank Dr. Anthony Fletcher and Marcelo Pinto Marcelli for specimens which they describe in this paper.



Figs. 1-4. Holotypes of Bulbothrix and Hypotrachyna. 1, Bulbothrix australiensis; 2, B. lopezii; 3, B. oliveirai (X10); 4, Hypotrachyna meridensis (for all except Fig. 3 scale = mm).



Figs. 5-8. Holotypes of Parmotrema. 5, P. betaniae; 6, P. catarinae; 7, P. fumarprotocetraricum; 8, P. lobulatum (scale for all = mm).



Figs. 9-12. Holotypes of Parmotrema. 9, P. madilynae; 10, P. schindleri; 11, P. sorediiferum; 12, P. virescens (scale for all = mm).

MYCOTAXON

Vol. XXV, No. 1, pp. 95-99 January-March 1986

TAXONOMIC CONCEPTS IN THE ENDOGONACEAE: II. A FIFTH MORPHOLOGICAL WALL TYPE IN ENDOGONACEOUS SPORES

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Many Endogonaceae are known only from preserved collections of spores formed either ectocarpically or in sporocarps in soil. Their taxonomy is therefore necessarily based on the microscopic features of such spores, among which, details of wall construction are particularly useful. In a recent paper (Walker 1983), I described and illustrated four wall types that can be found surrounding the contents of spores in the Endogonaceae, and proposed a standardized form of graphical illustration, the murograph. This system has found some acceptance among other authors (Rothwell and Victor 1984, Schenck et al. 1984). Since that paper was written, a further wall type has been discovered that does not fit well into the categories already established.

The new wall type, which has some characteristics of both membranous and unit walls, was brought to my attention by Dr R. E. Koske, University of Rhode Island, and was originally found in some undescribed species of *Gigaspora* Gerd. and Trappe and an undescribed *Glomus* Tul. and Tul. species. The characteristics of the wall type are as follows:

- It is generally rather robust, being between 2 and 5 µm in thickness (Figure 1, c). This contrasts with the normal membranous wall, which is usually no more than 1 or 2 µm thick, and often much less than 1 µm (Figure 1, m).

- It is rather tough and flexible. Unlike the unit or laminated wall, it does not fracture readily when a spore is crushed (Figure 2), although, as with a

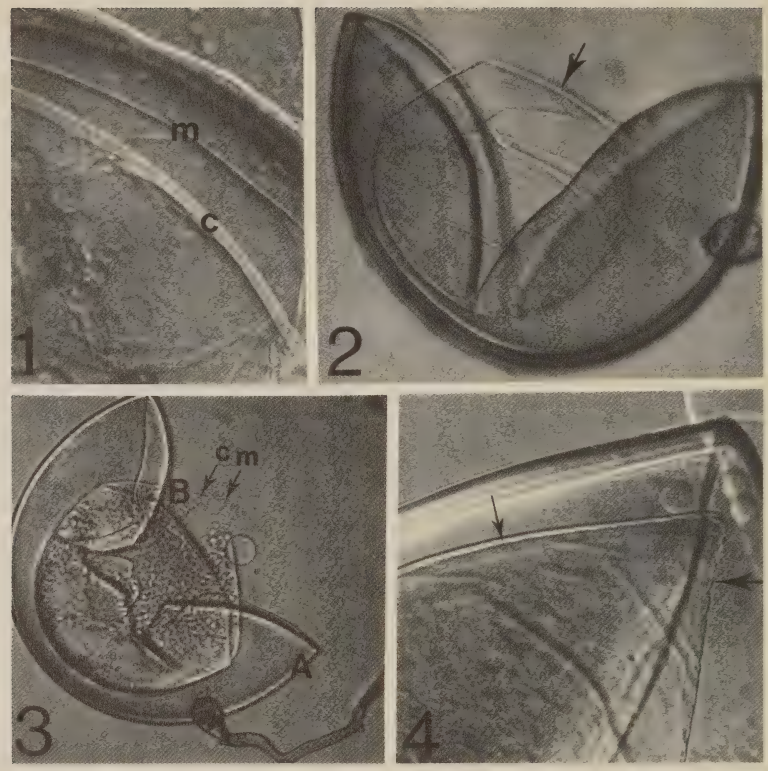

Figure 1. Crushed spore indicating the relative dimensions of membranous (m) and coriaceous (c) wall types.

Figure 2. Spore gently crushed showing the relatively tough, flexible nature of the coriaceous wall (arrowed) which remains unbroken.

Figure 3. Severe crushing in this specimen has fractured not only the outer wall group (A) but both membranous (m) and coriaceous (c) walls in the inner wall group (B).

Figure 4. Crushed spore showing the wrinkling of the outer surface that can occur with a coriaceous wall (large arrow). Optical interference has created an artefact which makes the wall appear laminated in this photograph (small arrow).

membranous wall, if excessive pressure is applied, it will break open (Figure 3).

- In hypertonic mounting media, the outer surface of the wall tends to wrinkle, and the whole wall shrinks as plasmolysis takes place. This gives the wall the appearance of old leather, smooth on the inner surface, but wrinkled externally (Figure 4). The wrinkling on the outer surface does not always occur, but the flexible nature, seen when a spore is crushed on a microscope slide or mounted in a hypertonic medium, and the dimensions of the wall serve to identify its nature even when this feature is absent.

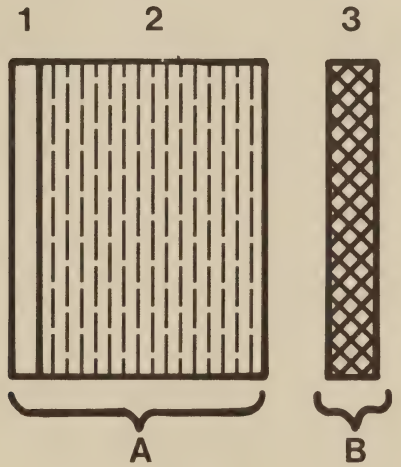

Figure 5. Murograph of a hypothetical endogonaceous spore with a unit wall (1) and a laminated wall (2) in an outer wall group (A) (after Walker 1983) and a coriaceous wall (3) in an inner wall group (B). The cross-hatching is suggested as a standardized representation of a coriaceous wall.

Because of the thick, leathery nature of this wall type, I propose to call it a CORIACEOUS wall. In construction of murographs, I suggest the use of 45° cross-hatching running in both directions (Figure 5).

Particular care should be taken to distinguish between laminated walls and coriaceous walls. In some species, the former occur among the walls of the inner wall group, and in such instances they may be more flexible than those found in the outer group. The rather thick nature of the coriaceous wall may cause refractions that create the impression of laminations when viewed through a light-microscope (Figure 4).

In using murographs for the study of endogonaceous spores, I have found that a formula consisting of writing down the initial letters of the walls in sequence from outer wall to inner wall provides a useful descriptive shorthand. Wall groupings can be represented by use of their designatory letter followed by the wall-type initials in parentheses, while ornamented walls can be indicated by adding a lower case letter 'o' after the appropriate initial letter. These formulae, which I term 'muronyms', are helpful in computer data retrieval systems, and can also be used in the construction of artificial keys to allow the rapid narrowing down of choice of species within a section of the key. Thus for the hypothetical spore illustrated in Figure 5, the muronym would be A(UL)B(C). To give examples from described species in the Endogonaceae *Glomus albidum* Walker and Rhodes, which has an evanescent wall and a laminated wall in a single group has a muronym A(EL), whereas for *Acaulospora nicolsonii* Walker, Reed and Sanders, which has two wall groups, the first with an evanescent wall, a laminated wall and a unit wall, and the second with a single membranous wall, it is A(ELU)B(M). For *Acaulospora spinosa* Walker and Trappe, which has its walls in two groups, with an ornamented unit wall attached to a laminated wall in group A, and two membranous walls in group B, it is A(UoL)B(MM).

ACKNOWLEDGEMENTS

I would like to thank Dr Rick Koske, University of Rhode Island for drawing my attention to the new wall type, and for his review of the manuscript. I would also like to

thank Dr S. C. Gregory, Forestry Commission, for his helpful comments. Thanks also to Shiela Swan, Forestry Commission, for typing the camera-ready copy.

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MYCOTAXON

Vol. XXV, No. 1, pp. 101-110 January-March 1986

MARINE PYTHIACEAE FROM DECAYING SEAWEEDS IN THE NETHERLANDS

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ABSTRACT

From decaying seaweeds collected in and near the salt lake Grevelingen (The Netherlands), several isolates of two species of Pythium and one species of Phytophthora were obtained. Pythium grandisporangium Fell & Master was isolated for the first time in Europe. Pythium chondricola sp. nov. is described, illustrated and compared with related species. The isolates of Phytophthora sp. did not develop oogonia. This species is described, illustrated and its probable taxonomic status is discussed.

INTRODUCTION

A number of Pythium and Phytophthora species have been isolated by different investigators, from marine habitats, mainly mangrove swamps, estuaries and salt marshes: Pythium aquatile Hohnk, P. grandisporangium Fell & Master, P. marinum Sparrow, P. porphyrae Takahashi & Sasaki, P. salinum Hohnk (see Van der Plaats-Niterink, 1981), Phytophthora vesicula Anastasiou & Churchland (1969), Ph. bahamensis , Ph. epistomium, Ph. mycoparasitica and Ph. spinosa vars. spinosa and lobata (all described by Fell and Master, 1975), Ph. operculata Pegg & Alcorn (1982) and Ph. avicennae, Ph. batemanensis and Ph. polymorphica (Gerretson-Cornell and Simpson, 1984).

Although most of the marine Pythiaceae were found in the last two decades, the results of Anastasiou and Churchland (1969), Fell and Master (1975) and Gerretson-Cornell and Simpson (1984) indicate that at least some species are quite common. In order to investigate marine Pythiaceae along the Netherlands coast, I collected and examined, a number of decaying seaweeds (including Chondrus crispus and Ulva lactuca) and leaves of Zostera marina, in 1983 and 1984. Isolates of two species of Pythium were found and they are described below. One of the species turned out to be identical with P. grandisporangium Fell & Master, and the other differs from

any known species. In addition a heterothallic species of Phytophthora was isolated.

MATERIAL AND METHODS

Both apparently healthy and decaying seaweeds and seagrass leaves were collected in October 1983 and September 1984 in Lake Grevelingen (a former estuary, now enclosed, salinity about 3.6%), in the south-western part of the Netherlands, and in two other localities, close to this lake, viz. the Oosterschelde estuary and in the North Sea. Collected material was transported in seawater in plastic bottles to the laboratory, where it was stored overnight at 5°C.

Isolations were made on cornmeal agar, prepared with half strength artificial seawater (salinity 1.8 %) (Hw-Meeressalz, H. Wiegandt, Krefeld, in tap water). This medium was used with and without penicillin and/or benomyl, to suppress bacteria and other fungi respectively. Small pieces of thallus or leaves were rinsed in sterile, artificial seawater, blotted on filter paper and put on the agar. After a few days at 17.5°C the resulting pythiaceous mycelium was subcultured. If necessary, the mycelium was purified on cornmeal agar containing penicillin and streptomycin.

The isolates were grown on cornmeal agar prepared with both tap water and artificial seawater at salinities of 1.8 and 3.6 %, to study mycelial growth and oogonium production. Growth was also observed on potato-carrot agar. For preparation of the agar media see Van der Plaats-Niterink (1981). For studies of sporangium development water cultures were used: colonized grass leaves (for Pythium) or hemp seeds (for Phytophthora) in the soil extract described below, and in artificial sea water at salinities of 0.036, 1.8 and 3.6%, prepared with distilled water. Soil extract was prepared by shaking 400 g of sandy soil with 1 l of distilled water and then filtering and autoclaving the extract. Water cultures were kept at room temperature (20 ± 3°C).

DESCRIPTION OF THE SPECIES

Pythium chondricola De Cock sp. nov. (fig. 1)

Species homothallica. Coloniae in agaro farina maydis confecto submersae, indistincte rosulatae. Hyphae radiantes 2.5-6 µm, vulgo 4 µm latae. Intumescentiae intercalares, raro terminales, globosae vel subglobosae, 10-29 µm diam. Sporangia filamentosa, non-inflata; tubi

evacuationis longissimi, 2-3 µm lati, apicem versus ad 7-8 um dilatati. Zoosporae in aqua marina normali vel diluta circa 20°C formatae, cystides 10-15 µm diam. Oogonia saepe conglomeratae, plerumque intercalaria, nonnumquam terminalia, (sub-)globosa, saepe partem hyphae originalis comprehendentia, levia plerotica vel aplerotica undulata, (14-)16-24(-34) µm diam. Antheridia 1-3(-4), diclina, stipites nonnumquam furcata, cellulae antheridiales saccatae vel claviformes, apices oogonio fere late adnati. Oosporae pleroticae vel nonnumquam apleroticae, parietibus ad 1.5 µm crassis.

Typus CBS 203.85, vivus et exsiccatus, isolatus e Chondro crispo putrido, ad Lacum Grevelingen, prope Grevelingendam, in Neerlandia, A.W.A.M. de Cock, 1983.

Homothallic species. Colonies on cornmeal agar submerged with a vague, irregularly rosette/chrysanthemum pattern. Main hyphae 2.5-6 µm , mostly 4 µm wide. Hyphal swellings present in agar cultures, intercalary, occasionally terminal, (sub-)globose, 10-29 µm diam. Sporangia filamentous, not inflated; discharge tubes very long, 2-3 µm wide, widening at the tip to 7-8 µm. Zoospores formed at room temperature in artificial sea water at salinities between 0.036 and 3.6 %. Encysted zoospores 10-15 um diam. Oogonia formed on cornmeal agar with tap water or 1.8% seawater agar, often concentrated in macroscopically visible white groups, mostly intercalary, occasionally terminal, (sub-)globose, often including a part of the subtending hypha, colourless, smooth or, if aplerotic oospores are present, with undulate wall, (14-)16-24(-34) µm diam. Antheridia 1-3(-4) per oogonium, diclinous, antheridial stalk sometimes branched, antheridial cell sac-like to club-shaped, tip rather broadly attached. Oospores plerotic, occasionally aplerotic, wall to 1.5 um thick. Cardinal temperatures for growth: minimum 3°C, optimum 24°C, maximum 31°C. Daily growth rate on cornmeal agar at 24°C: 5 mm, on cornmeal/1.8% seawater agar 5.5 mm, on cornmeal/3.6% seawater agar 3.5 mm, on potato-carrot agar (after a lag period of some days) 3-4 mm.

Material examined: CBS 203.85, type strain, isolated from decaying Chondrus crispus in Lake Grevelingen, near the Grevelingendam, 1983. CBS 204.85 and CBS 205.85 from the same origin and locality; CBS 206.85 from decaying Ulva lactuca, CBS 207.85 from decaying leaf of Zostera marina, both in Lake Grevelingen, 1983; CBS 208.85 from decaying unidentified red alga, CBS 209.85 from decaying Ulva lactuca, both in the Oosterschelde estuary, near Colijnsplaat, 1984; CBS 210.85, single zoospore isolate from CBS 208.85, and some more isolates not maintained.

Discussion.

Pythium chondricola is a species with some highly variable characters. The oospores may be distinctly

plerotic as well as aplerotic. Some isolates have both types, whereas others may have nearly 100% of one type.

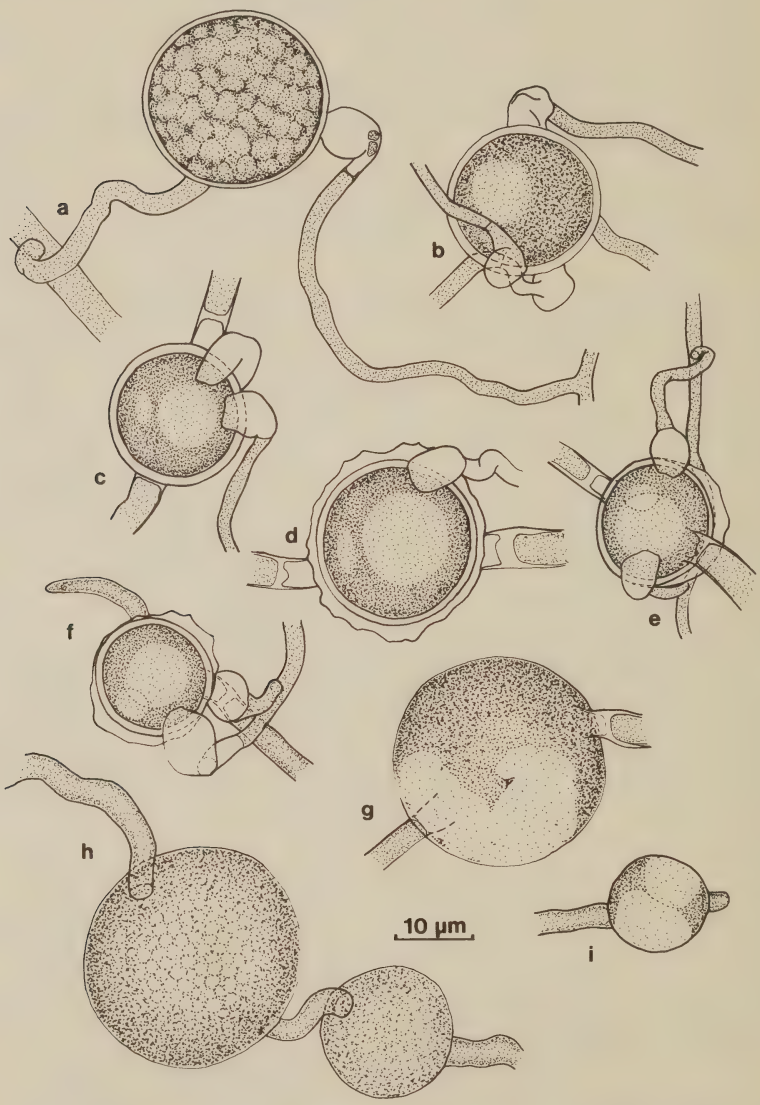

Fig 1. Pythium chondricola sp. nov.-- a-c. Oogonia with plerotic oospores.--d-f. Oogonia with aplerotic oospores and undulate wall.--g-i. Hyphal swellings.

Rarely two oospores are present in an oogonium. In some isolates oogonia that failed to develop mature oospores often had a larger diameter than oogonia with well developed, mature oospores. Moreover, the number of antheridia present on these oogonia was sometimes quite high: up to and even more than ten, whereas the normal number of antheridia on well-developed oogonia was one to four. Antheridia are sometimes also present on hyphal swellings.

Pythium chondricola belongs to the group of species with filamentous, non-inflated sporangia. In this group three species with hyphal swellings occur: P. porphyrae Takahashi & Sasaki, P. perniciosum Serbinow and P. sulcatum Pratt & Mitchell. P. chondricola is closely related to P. porphyrae: besides the sporangium type, common characters are the presence and position of hyphal swellings, position of oogonia, type and number of antheridia and hyphal diameter. P. chondricola differs from P. porphyrae in having also aplerotic oospores, larger oogonia, thinner oospore walls and considerably lower cardinal temperatures. Unfortunately the CBS strains of P. porphyrae are in a degenerate condition: 367.79 did not form well-developed, mature oospores and 517.82 only a few. The thickness of the oospore wall in both isolates was 1-4 µm, mostly 2-2.5 µm. In P. chondricola the oospore wall is mostly less than 1.5 µm (rarely up to 2 µm). The wall of plerotic oospores is often even less than 1 µm thick. P. perniciosum has catenulate hyphal swellings that are easily shed and differs in almost every other character from P. chondricola; P. sulcatum has monoclinous antheridia, longitudinally appressed to the oogonium. Among species lacking hyphal swellings P. chondricola differs from P. aquatile Hohnk, P. tenue Gobi, P. monospermum Pringsh., P. dissotocum Drechsler, P. coloratum Vaartaja and P. angustatum Sparrow in having strictly diclinous antheridia and plerotic oospores, from P. adhaerens Sparrow by antheridia borne on mainly unbranched stalks, not encircling the oogonium, and by thinner oospore walls, from P. marinum Sparrow by intercalary oogonia and the presence of mostly more than one antheridium, from P. diclinum Tokunaga and P. apleroticum Tokunaga by the mainly intercalary oogonia, higher number of antheridia, lower cardinal temperatures and slower growth rate. It is also distinct from P. papillatum Matthews as this species lacks antheridia completely and may have papillae on the oogonia.

Pythium grandisporangium Fell & Master - Can. J. Bot. 53: 2920-2921. 1975 (fig. 2).

Colonies on cornmeal agar submerged, without a recognizable pattern, becoming yellowish with age, due to the development of oogonia. Main hyphae up to 7.5 µm wide. Hyphal swellings and appressoria not observed. Sporangia

developing in 3.6% sea water only, terminal, the long axis occasionally perpendicular to the subtending hypha, most typically globose with a beak (fig. 2 f-h), but many sporangia irregularly obclavate, 55-165 x 25-88 µm.

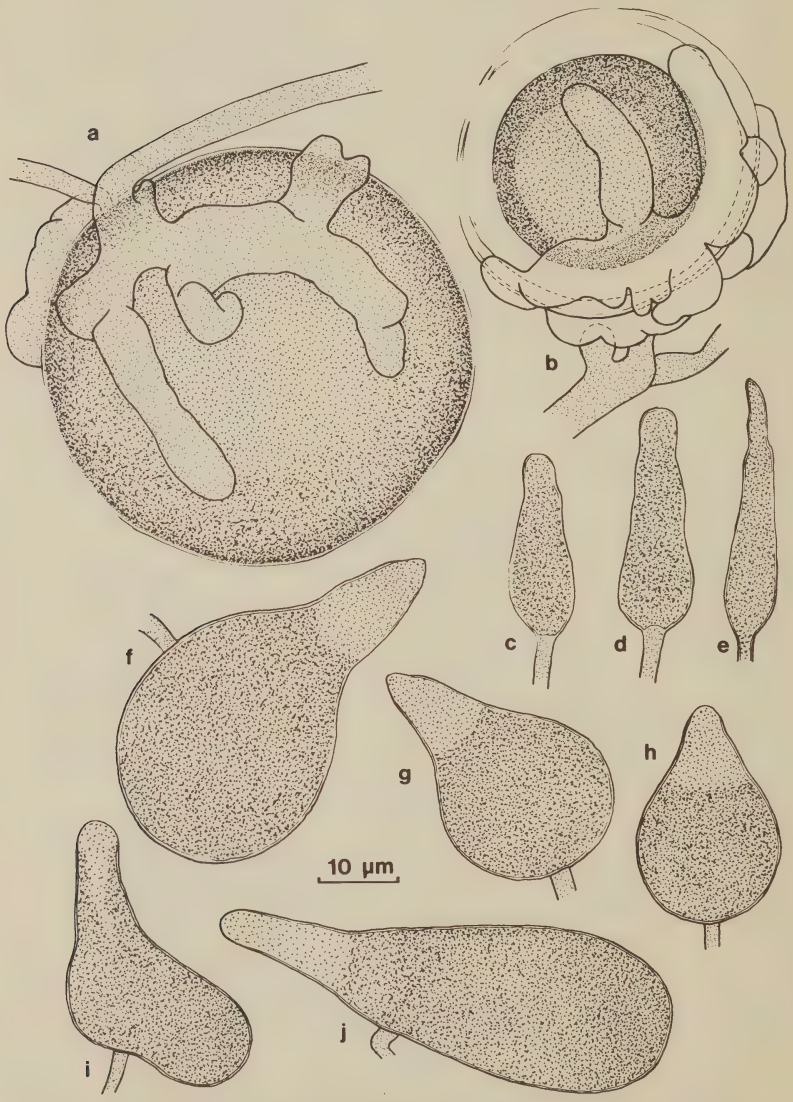

Fig 2. Pythium grandisporangium Fell & Master.-- a, b. Oogonia.--c-e. Young, developing sporangia.--f-j. Mature sporangia.

Oogonia terminal, globose, smooth, rarely with a single finger-like projection, (21-)27-48(-60) µm diam. Antheridia 1(-2, possibly 3) per oogonium, antheridial cell irregularly lobed and branched, broadly appressed to the oogonium, close to the oogonial stalk. Origin of the antheridia difficult to trace, probably both monoclinous and diclinous types occurring. Oospores single, slightly aplerotic, globose, 20-56 um diam, wall (2-)4-6(-7) µm thick. Cardinal temperatures for growth: minimum below 0°C, optimum 27°C, maximum about 30°C. Daily growth rate on cornmeal agar at 24°C 10 mm, on cornmeal/1.8% seawater agar 20 mm, on cornmeal/3.6% seawater agar 16 mm.

Material examined: CBS 211.85, CBS 212.85, CBS 213.85 and CBS 214.85 from decaying leaves of Zostera marina L., Lake Grevelingen, and several isolates from the same origin, not maintained. CBS 286.79, type strain, isolated from leaves of Distichilis spicata submerged in 3% seawater in a salt-marsh, dwarf mangrove area inland from Little Card Sound, Florida, J.W. Fell and I.M. Master, 1973; CBS 606.81, isolated from Fucus distichus L., near Skookumchul tidal rapids in southern British Columbia, Canada, by T.A. Thompson, 1980.

Discussion

Thus far P. grandisporangium was known in the literature only from its original isolate from Florida. A secundary isolate from Canada, maintained at CBS, agrees with the type strain. The isolates from Lake Grevelingen show only slight differences from the type strain: the maximum size of oogonia is somewhat larger, the oospores are slightly aplerotic and the oospore walls may be somewhat thicker. The growth rate on cornmeal/1.8% seawater agar is considerably higher. Examination of the type strain showed that this isolate also develops many slightly aplerotic oospores.

Phytophthora sp. (figs. 3, 4)

On cornmeal agar colonies coarsely radiate, submerged or with thin aerial mycelium; amount of aerial mycelium decreasing with increasing salinity of the medium. On agar only mycelium with occasionally inflated hyphae and hyphal knots are developed. Hyphae 5 µm wide in water, up to about 8 um on agar. Soil extract and 1.8% seawater proved to be the best media for development of sporangia and hyphal swellings. In both media zoospore release and cyst germination were observed. Large complexes of irregularly inflated hyphae developed in these media. Hyphal swellings (sub-)globose, intercalary and terminal, single, occasionally catenulate and often in complexes together,

(22-)30-50(-70) µm diam. Sporangia terminal, internally proliferating, ovoid to obturbinate, non-papillate, with a slight apical thickening, 45-80 x 30-52 um, apical opening 12-17 um wide. Zoospore discharge directly or by a vesicle, cyst diameter 13 um. Oogonia and antheridia absent from both agar cultures and water cultures. Cardinal temperatures for growth: minimum below 0°C, optimum 27°C and maximum 34°C. Daily growth rate on cornmeal agar at 24° 10-8 mm (decreasing in time), on cornmeal/1.8% seawater agar 12.5 mm, on cornmeal/3.6% seawater agar 14.5 mm.

Material examined. CBS 215.85, CBS 216.85, CBS 217.85, isolated from decaying leaves of Zostera marina and CBS 218.85, from decaying Chondrus crispus, all in Lake Grevelingen, Near the Grevelingendam, 1983; CBS 268.85 from decaying leaf of Z. marina in the same locality, 1984.

Discussion

The Phytophthora isolates from Lake Grevelingen are probably identical to the marine Phytophthora isolates of Hohnk (1953). They are easily to be distinguished from Ph. bahamensis, Ph. epistomium, Ph. mycoparasitica, Ph. spinosa var. spinosa, Ph. spinosa var. lobata, Ph. vesicula and Ph. operculata as all these marine species have unique methods of zoospore release; the Dutch

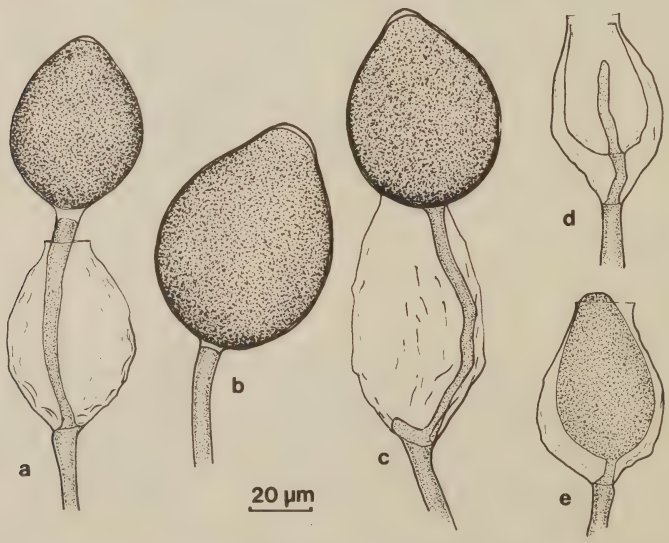

Fig 3. Phytophthora sp.--a-e. Sporangia in various stages of development and proliferation.

isolates differ from Ph. avicennae, Ph. batemanensis and Ph. polymorphica by the smaller sporangia, internal proliferation and development of hyphal swellings. The Grevelingen isolates belong to the group of heterothallic Phytophthora species with internally proliferating, non-papillate sporangia. The isolates seem to be identical with Ph. japonica Waterhouse (=Pythiomorpha oryzae Ito &

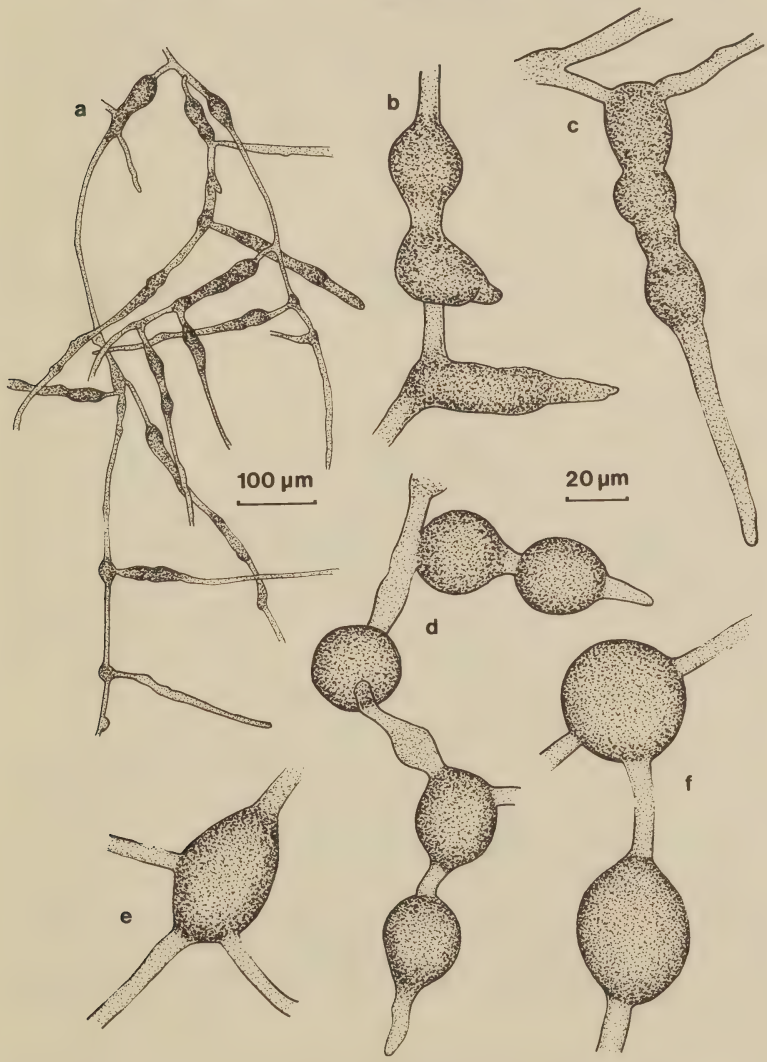

Fig 4. Phytophthora sp.-- a. Complex of inflated hyphae.-- b-f. Inflated hyphae and globose hyphal swellings.

Nagai); the original description by Ito and Nagai (reproduced in Waterhouse, 1970) fits the marine isolates perfectly, even in the absence of a sexual stage. Only the differing origins of Ph. japonica and the marine isolates raise questions. Waterhouse (1958) succeeded in culturing oogonia in Ph. japonica; the marine isolates gave positive results in mating experiments with some other heterothallic Phytophthora isolates, but the oogonia developed were not similar to the oogonia described by Waterhouse and were probably produced by the mating partner, as they always appeared in that half of the dish. Establishment of the specific identity of the marine Phytophthora isolates from Lake Grevelingen must await further study, especially of the sexual stage.

ACKNOWLEDGEMENTS

I thank Mrs. A.J. van der Plaats-Niterink for her valuable comments and Mr. Keith A. Seifert for correcting the English text.

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MYCOTAXON

Vol. XXV, No. 1, pp. 111-117 January-March 1986

A NEW SPOROCARPIC SPECIES OF ACAULOSPORA (ENDOGONACEAE)[1]

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ABSTRACT

A new species of *Acaulospora*, *A. myriocarpa*, a mycorrhizal-forming fungus in the Endogonaceae (Endogonales, Zygomycetes) is described. This hyaline, small-spored species forms spores singly in soil and roots but also produces them in sporocarps and sporulates in soil crevices, within empty seed teguments, cast insect exoskeletons, and empty spores of other Endogonaceae. Spores of *A. myriocarpa* are of similar size and appearance to *A. trappei*. Spores detached from the hyphal terminus can be confused possibly with *Glomus occultum*, *G. diaphanum* and *G. microcarpum*. The known distribution of *A. myriocarpa* is restricted to Colombia and Peru.

INTRODUCTION

A small-spored, hyaline, sporocarp-forming species of *Acaulospora* was observed first in Carimagua, Meta, Colombia in 1981. On first examination, this species was perplexing because spores associated with this fungus could be placed in the genera *Glomus*, *Entrophospora* and *Acaulospora* based on their configuration with or without the hyphal terminus. In addition, until recently (Berch, 1985), no species of *Acaulospora* was known to form sporocarps. The purposes of this paper are to describe this new fungus, compare it to species of similar morphology and size and discuss some of its unique features. Spore wall terminology follows that of Walker (1983).

[1] Florida Agriculture Exper. Stat. Jour. Series No. 6687

ACAULOSPORA MYRIOCARPA Spain, Sieverding et Schenck (Figs. 1,2 and 3)

Sporae singulatim in terra vel in sporocarpiis efformatae; sporocarpia irregularia, hyalina,parva,725 X 525 µm vel magna 22 X 8 mm, sine periodio; sporae penduculo gestae vel sporae sessiles, in subattenuata hypha cum terminatione inflata globosa. Sporae hyalinae, globosae vel subglobosae, 32-90 µm diam., vel irregulares, 28-95 X 28-80 µm. Tunicae sporarum 1.5-3.5 µm crassae; tunica exterior rigida, hyalina, 0.75-2 µm crassae, secundo interior rigida, hyalina, 0.3-1.5 µm crassae, tertio membranaceo (<0.3 µm crasso) inseparabili e tunica secundo. Sporae cum pedicellibus aliquando. Formans mycorrhizas sed sine vesiculis vel arbusculis.

Spores formed singly in the soil and adjacent to roots or in irregular-shaped small, 725(-1050) X 525(-906) µm, to occasionally large, upto 22 X 8mm, sporocarps without a peridium; spores frequently formed within soil crevices and inside roots, empty spores of other Endogonaceae, within insect carapaces, and old seed testa. Spores borne on a short pedicel, 2.8-12 long X 2.7-8 µm wide, or sessile on a slightly tapering hypha, 5-8 µm wide, terminating in a globose to ovoid terminus, 25-100 X 30-95 µm; hyphal terminus contents hyaline to subhyaline, granular to reticulate; terminus wall 0.5-0.75 µm thick; as the spore forms the terminus empties, collapses and the terminus hypha proximal to the pedicel may attenuate. Spores hyaline, mostly globose to subglobose, (22)32-90 µm, or cylindrical, ovoid, pyriform to irregular, (23)28-95(114) X (21)28-80(96) µm; spore contents hyaline and granular; composite spore wall hyaline, 1.5-3.5(7) µm thick, of 3 walls (1-3) in one group; wall 1 rigid, 0.75-2 µm, wall 2 rigid 0.3-1.5 µm; spore walls staining dull yellow in Melzer's reagent; wall 3 membranous (<0.3 µm thick) closely appressed to wall 2, seen best in stained preparations; hyphal pedicel occasionally (10-20% of spores) remaining attached to the spore after separation from the hypha and terminus. Hyphae within the root staining faintly with trypan blue and no typical vesicles or arbuscules observed.

TYPE: Obtained from a pot culture with Pueraria phaseoloides (Roxb.) Benth. (tropical kudzu), culture C-7 at Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia; originally collected by Joyce Spain from native grasses in an acidic loam (pH 4.5) at Reserva-Carimagua, Meta, Colombia. Holotype OSC; isotypes FLAS and FH.

SPECIMENS EXAMINED: Numerous specimens of A. myriocarpa were collected from several regions in Colombia. Spore sizes of pot-cultured isolates of these specimens varied considerably but because of the gradual overlap in spore

diameter among the isolates on P. phaseoloides (Fig. 4) they were considered variants of the holotype rather than new taxa. Paratypes: (listed with CIAT pot culture numbers and followed by spore diameter measurements) C-4-10 associated with roots of Manihot esculenta Crantz in acid clay, Mondomito, Cauca; 27-57 µm. C-20-5 associated with roots of M. esculenta in acidic sand, Alegria-Carimagua, Meta; 40-90 µm. C-22-1 associated with roots of Allium porrum L. in red clay loam, farm of Mr. Baron, Bitaco, Valle; 51-82 µm. C-29-4 from soil for greenhouse experiments in Quilichao, Cauca; 30-61 µm. C-37-7 associated with roots of Stylosanthes sp. at the CIAT field station in Quilichao, Cauca; 45-75 µm. C-44-6 associated with roots of native grasses at Piragua Grande near Buenaventura, Valle; 33-65 µm. C-88-1 from soil on the CIAT station at Popayan, Cauca, collected by J. Haanschoten; 31-51 µm. C-94-3 associated with roots of M. esculenta at site D-4 on the CIAT station, Quilichao, Valle; 33-50 µm. C-98-2 from a pot culture (Car-45) of Acaulospora appendicula Spain, Sieverding & Schenck on P. phaseoloides at CIAT, Cali, Cauca; 41-64 µm. C-100-3 from a pot culture (Car-29) of A. appendicula on P. phaseoloides at CIAT, Cali, Cauca; 30-45 µm. Sporocarps were not found with all the above isolates but all spores had two walls. All the paratypes have been sent to the OSC herbarium. Also observed in Tarapoto, San Martin, Peru at two locations associated with roots of tropical grasses and legumes (pot culture C-46-7) and with roots of Brachyaria sp. (pot culture C-47-6).

ETYMOLOGY: Myriocarpa (Gr. Myrio = innumerable; L. carpa = fruit) referring to the abundance of spores and sporocarps produced by this species.

MYCORRHIZAL ASSOCIATIONS: Known to form mycorrhizal associations with Peuraria phaseoloides, Manihot esculenta, Coffea arabica L., Brachyaria sp., Stylosanthes sp., and Allium porrum L.

DISTRIBUTION: Known only from Colombia and Peru.

DISCUSSION

Some spores of A. myriocarpa, especially those which were stained with trypan blue or cotton blue, have a separation between the inner wall and a membrane retaining the spore contents. The thickness of this membrane was not possible to determine accurately with a light microscope (X1250) in unstained spores because of its thin nature and its adherence to the inner rigid wall. In stained preparations, this membrane separated from the inner rigid wall and measured less than 0.3 µm in thickness. This increased thickness of the membrane in stained spores may have resulted from stain particle

deposition. This membranous wall is included in the murograph (Fig. 2) but is labeled with an asterisk as being difficult to see.

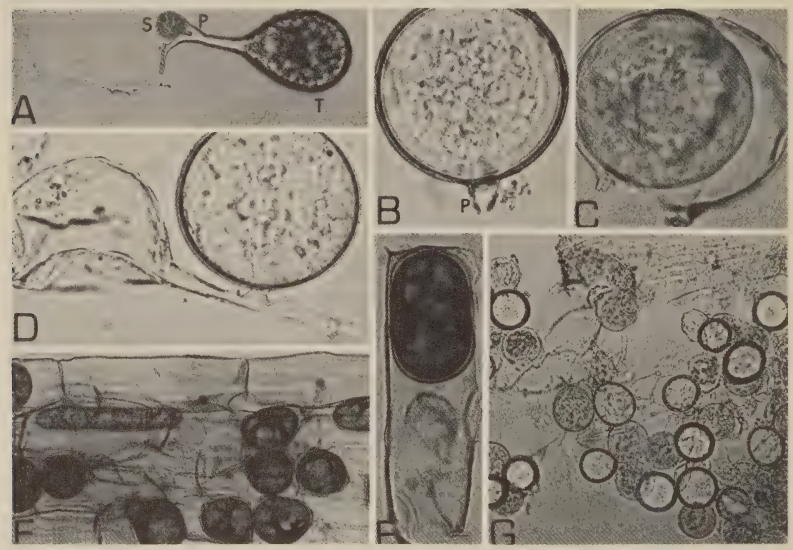

FIG. 1. Acaulospora myriocarpa. A) Initial stages of spore formation. (T=hyphal terminus; P=pedicel; S=initial spore) X250. B) Mature spore with attached pedicel (P) X400. C) Broken outer wall on mature spore, X400. D) Mature spore attached to pedicel, hypha, and collapsed terminus, X400. E) Spores (stained with trypan blue) in a root, X400. F) Mature spore (stained with trypan blue) and collapsed terminus in a single cortical cell, X400. G) Mature spores at the edge of a broken sporocarp, X250.

The only other sporocarp-forming species of Acaulospora, A. sporocarpia Berch, (Berch, 1985) can be readily separated from A. myriocarpa. Spores of A. sporocarpia are dark brown to black, are considerably larger (160-200 X 150-175 µm) than A. myriocarpa, and are formed in dark brown sporocarps. However, A. myriocarpa can be easily confused with A. trappei Ames & Linderman because both species produce spores that are hyaline, thin walled, of similar size and both form spores in roots. Spores of A. myriocarpa in sporocarps would readily be separable from A. trappei since A. trappei does not form sporocarps. In addition, spores of A. myriocarpa have two distinct walls and spores formed singly in soil frequently

have a pedicel attached, features absent in A. trappei. However, many spores of A. myriocarpa lack a pedicel or the pedicel can be lost by abrasion in soil.

Single spores of A. myriocarpa with a pedicel can sometimes be confused with Glomus species (Fig. 1B), especially spores of G. occultum Walker, G. diaphanum Morton & Walker and G. microcarpum Tul. & Tul. Spores of A. myriocarpa and both G. diaphanum and G. occultum have two separable walls. Glomus diaphanum has the inner wall inserted into the hyphal attachment and this arrangement can be seen when spores are broken and the two walls disassociate. This does not occur with A. myriocarpa. Glomus occultum has a thin outer wall that is frequently associated with debris and a thicker inner wall. In A. myriocarpa the outer wall is slightly thicker than the inner wall (Fig. 2) and no debris is associated with the outer wall (Fig. 1 B,C and D). With G. microcarpum the spore wall is single, frequently has laminations, and is some what thicker (4-6 µm) than that of A. myriocarpa (1.5-3.5 µm).

As mentioned earlier, our first observations of A. myriocarpa revealed spore types that resembled three genera. Typical Acaulospora-like attachments to the spore were observed but in addition Entrophospora-like attachments were noted. These resulted from the attenuation or loss of the proximal hypha associated with the tapering hypha at the pedicel (Fig. 3). This spore-terminus conformation much resembled that of Entrophospora. The Glomus-like appearance of the pedicel attached to the spore resulted when the separation of the spore from the hypha occurred at the point where the pedicel was attached to the tapering hypha (Fig. 1B; Fig. 3).

A word of caution is appropriate regarding research with and identification of small, hyaline-spored species of Endogonaceae. These species can be easily overlooked in soils, especially if very fine sieves (25 µm diam.) are not used routinely in surveys for mycorrhizal fungi. These hyaline, small-spored species can be a problem also when inoculating "control" pots with pot culture sievings to establish similar microflora to that which occurs in mycorrhizal inoculated treatments. Many of these spores are small enough in diameter, especially without their attached hyphae, to pass through most sieves routinely used to exclude spores of mycorrhizal fungi from these sievings. This can result in "control" treatments with mycorrhizae.

Many of these hyaline, small-spored species cannot be distinguished readily from each other with a dissecting microscope (X70-X100). A species determination may be impossible even if examined with a compound microscope,

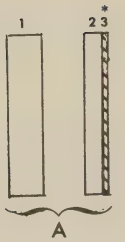

Fig. 2. Murograph of the wall structure of Acaulospora myriocarpa which consists of two unit walls and a thin membranous wall. Diagram after Walker, 1983.

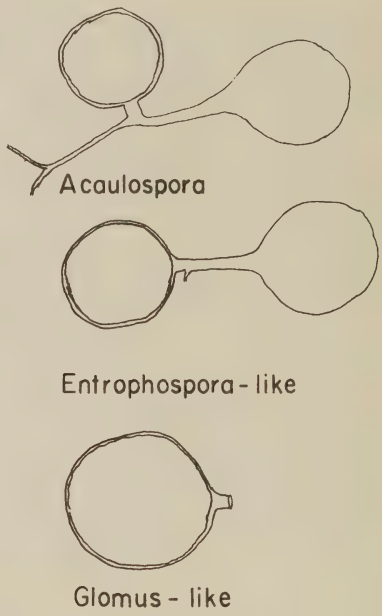

Fig. 3. Diagram of the spores of Acaulospora myriocarpa with and without the attached terminus showing the three configurations observed.

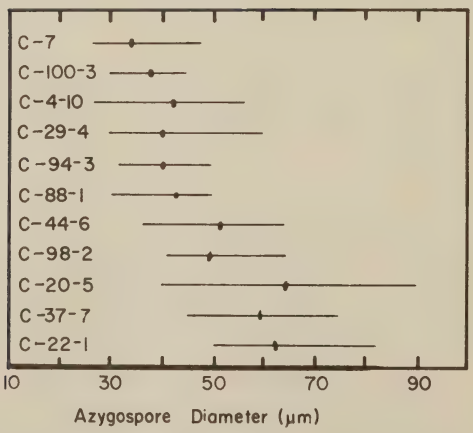

Fig. 4. Range of spore diameters of eleven isolates of Acaulospora myriocarpa. Mean spore diameter indicated by the mark on each line.

especially if hyphal attachments are missing. Therefore, we recommend establishment of pot cultures from single spores so that a positive determination can be made later on pot cultured spores with intact hyphal attachments and spores in different stages of maturity and development.

ACKNOWLEDGMENTS

We wish to thank J. B. Morton, R. E. Koske, G. W. Simone, J. W. Kimbrough, and T. Schubert for helpful suggestions and critical review of the manuscript, the laboratory staff of the Mycorrhizal Project at C.I.A.T. for their assistance, and the U.S.D.A. Title 406 Grant 58-7830-0-225 for financial assistance to the senior author.

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MYCOTAXON

Vol. XXV, No. 1, pp. 119-140 January-March 1986

SOME MORE OBSERVATIONS ON EASTERN HIMALAYAN HELOTIALES

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SUMMARY

Five new species and one new genus (Debaryoscyphus) of the Helotiales are recorded from the Eastern Himalayas. Two of the species belong to the Leotiaceae, namely Mollisinopsis aurantiaca and Debaryoscyphus melanobasis and three to the Hyaloscyphaceae, Dendrotrichoscypha tetraspora, Hyaloscypha himalayensis and Hyaloscypha uncinata. Unguiculella eurotioides is recorded from the Indian subcontinent for the first time. There are provided keys to the known species of Mollisinopsis and to the Indian species of Hyaloscypha.

ZUSAMMENFASSUNG

Fünf neue Arten und eine neue Gattung (Debaryoscyphus) der Helotiales aus dem östlichen Himalaya-Gebiet werden beschrieben. Zwei der neuen Arten gehören zu den Leotiaceen, nämlich Debaryoscyphus melanobasis und Mollisinopsis auran-

tiaca und drei zu den Hyaloscyphaceen: Dendrotrichoscypha tetraspora, Hyaloscypha himalayensis und Hyaloscypha uncinata. Unguiculella eurotioides wird zum ersten Mal für den indischen Subkontinent nachgewiesen. Zur Bestimmung der bekannten Mollisinopsis- und der indischen Hyaloscypha-Arten werden Bestimmungsschlüssel gegeben.

RESUME

Voici la description de cinq nouvelles espèces et d'un nouveau genre des Helotiales trouvés dans le Himalaya oriental. Deux des espèces nouvelles font partie des Leotiaceae, c'est-à-dire Debaryoscyphus melanobasis et Mollisinopsis aurantiaca, trois des Hyaloscyphaceae: Dendrotrichoscypha tetraspora, Hyaloscypha himalayensis et Hyaloscypha uncinata. Unguiculella eurotioides (Karst.) Nannf. est documentée pour la première fois dans le sous-continent indien. On présente des clefs de determination pour les espèces publiques de Mollisinopsis et les espèces indiennes de Hyaloscypha.

This is a continuation of a series of papers about Eastern Himalayan Helotiales collected by the senior author in recent years (cf. e.g. ARENDHOLZ & R. SHARMA 1983 and 1984). The methods are the same as described there. In addition the junior author used an old threefold colouring, which was developed by GUEGEN (1906). The reagent contains SUDAN III, cotton blue and iodine, which were dissolved in pure lactic acid. SUDAN III stains fats, e.g. as oil drops in the ascospores, cotton blue tinges - among other things - the cytoplasm, and iodine shows the J+ reaction of the tips of the asci and, if present, colours reserve substances as e.g. glycogen. The colouring yields nice pictures in the light microscope, especially of the ascospores, if these contain oil drops, which stand out red against the blue coloured cytoplasm.

All collections cited in the text have again been deposited in PAN (Panjab University, Botany Department, Herbarium) and duplicates in the junior author's personal herbarium, as indicated.

MOLLISINOPSIS AURANTIACA Arendholz & R. Sharma sp. nov.

FIGS.: Plate 1: Fig. 1-6, Plate 2: Fig. 5.

Apothecia gregaria ad sparsa, sessilia ad breviter stipitata, cupulata ad plana, ad 0.25 mm diam. et ad 0.3 mm alta. Receptaculum fulvum, in sicco luteolum, subtiliter villosum, pili parvi, continua, ad 20 x 6 µm, apex simplex ad furcatus, varie curvatusque. Hymenium pallide aurantiacum, in sicco luteolum. Excipulum ectalum ex textura intricata, hyphae leptodermae, in gelatina inclusae, exciplum medullatum ex textura intricata, hyphae sicut in excipulo ectalo. Asci tetraspora, 68-81 x 10-11 µm, clavati-cylindrici, apex rotundus, poro jodo caerulescente. Ascosporae hyalinae, 11-13 x 3-4.5 µm, ellipsoideae, uniseptatae, in medio constrictae, guttulatae, ad maturitatem evanescente, involutae in tunica gelatinosa crassa, uniseritae. Paraphyses ad 2 µm latae, filiformes, simplices, ad ramosae, angustae, ascos ad 20 µm superantes.
Holotypus. - In calamo emortuo angiospermo, Chimakothi, Bhutan, September 23, 1980, R. Sharma, 17758 (PAN), isotypus 24083 (PAN); W.R.A.

Apothecia gregarious to scattered, sessile to short stalked, shallow cupulate to plane, margin finely crenate, external surface yellowish brown, drying pale luteous, minutely downy. Hymenium light orange, drying pale luteous, up to 0.25 mm in diam. and up to 0.3 mm in height, dark brown at the point of attachment with the substrate.

Ectal excipulum of textura intricata, up to 75 µm thick, glassy, hyphae thin-walled, embedded in a gelatinous matrix, up to 25 x 10 µm, outermost cells drawn out into hairs. Hairs small, smooth, up to 20 x 6 µm, one-celled, the apex of which is simple to forked and variously curved.

Medullary excipulum of textura intricata, up to 50 µm thick, hyphae thin-walled, septate, up to 2 µm wide.

Asci 4-spored, J+, 68-81 x 10-11 µm, clavate-cylindric, apex round, base stem-like.

Ascospores hyaline, 11-13 x 3-4.5 µm, ellipsoid, one-septate, constricted in the middle, filled with innumerable minute guttules, which disappear at maturity, enveloped in a thick, hyaline gelatinous sheath up to 7 µm thick, uniserate.

Paraphyses filiform, simple or branched, narrow, up to 2 µm wide at the top, projecting up to 20 µm beyond the tips of

the asci.

Etymology of the specific epithet. - Refers to the colour of the hymenium in the fresh condition.

Habitat. - On dead angiosperm stem.

Type locality. - Chimakothi, Bhutan.

Holotype. - September 23, 1980, Raghunandan Sharma, PAN 17758. Specimens examined: Isotypes PAN 24083, on dead angiosperm stem, 5 km from Jamiri towards Nachephu, West Kameng, Arunachal Pradesh, September 12, 1981, Raghunandan Sharma; and in the junior author's personal herbarium (W.R.A. 1984-1020, 1984-1021).

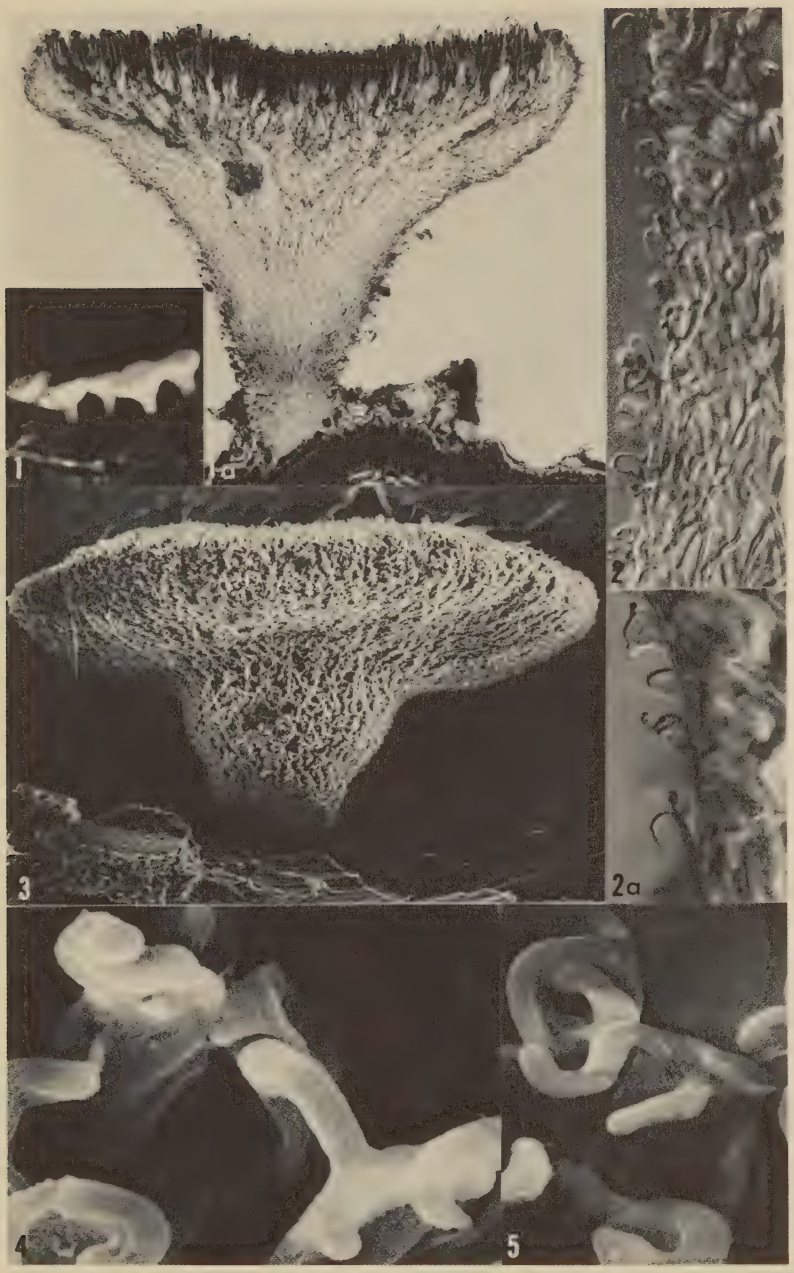
NOTES. - Because of its anatomical characters this species fits rather well into the genus MOLLISINOPSIS Arendholz & R. Sharma (ARENDHOLZ & R. SHARMA 1984), although the "branches" of the hairs show a weak striation, as revealed by SEM studies and which here is more marked than in either of the other species of MOLLISINOPSIS (M. indica and M. filicis; cf. ARENDHOLZ & R. SHARMA 1983, 1984). Whether this stritiation is an artifact or a consistant existing character has to be studied in fresh material, which is critical point dried.

Plate 1

MOLLISINOPSIS AURANTIACA Arendholz & R. Sharma sp. nov.; PAN 24083, Fig. 1-3, 5; PAN 17758: Fig. 4

Fig. 1: A group of Apothecia seen under the stereomicroscope; 47 x.
Fig. 1a:LS*) through an apothecium; 160 x, BF*).
Fig. 2, 2a: LS showing part of the ectal excipulum with hairs; 630 x DIC*).
Fig. 3: One apothecium showing downy excipulum; SEM picture, 150 x.
Fig. 4: Some hairs of the ectal excipulum showing striation; SEM picture, 7200 x.
Fig. 5: ditto; SEM picture, 5400 x.
(photos: W.R. Arendholz)

*) LS = longitudinal section; BF = bright field; DIC = Nomarski differential interference contrast.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Following is a key to the known species of MOLLISINOPSIS:

1	Ascospores more than 10 µm long, 1-septate, constricted in the middle	M. aurantiaca
1*	Ascospores shorter than 10 µm, one-celled, not constricted in the middle	2
2	Ascospores 3.5-4.0 x 1.5-2.0 µm, growing on dead, fallen leaves and culms of grasses	M. indica (Cf. AREND-HOLZ & R. SHARMA 1983)
2*	Ascospores 5.5-7 x 1-1.5 µm, growing on dead fern stipes	M. filicis (Cf. AREND-HOLZ & R. SHARMA 1984)

HYALOSCYPHA UNCINATA Arendholz & R. Sharma sp. nov.

FIGS. Plate 2: Fig. 1-4, 6; Plate 3: Fig. 5, 7

Apothecia gregaria, parva, mollia, sessilia, plana ad convexa, ad 1 mm diam. Receptaculum albidum, subtiliter villosum, pili uncinati, simplices ad furcati ad apicem, ad 30 x 3 µm. Hymenium concolorum cum receptaculo, in sicco umbrinum ad ochraceum. Ectal excipulum ex textura prismatica, excipulum medullatum ex textura intricata. Asci octospori, e uncis nati, 55-65 x 7-7.5 µm, clavati-cylindrici, apex rotundus, poro jodo caerulescente. Ascosporae hyalinae, 8.5-12 x 2-3 µm, ellipsoideae, biguttulatae, oblique uniseriatae ad irregulariter biseriatae. Paraphyses hyalinae, filiformes, ramosae, septatae, ad 3 µm latae, ascos ad 15 µm superantes. Holotypus. - In superficiebus ambabus foliourum emortuorum.

Plate 2

HYALOSCYPHA UNCINATA Arendholz & R. Sharma sp. nov.; PAN 17833: Fig. 1-4. 6; MOLLISINOPSIS AURANTIACA Arendholz & R. Sharma sp. nov.; PAN 24083: Fig. 5

Fig. 1: LS showing part of the excipulum at the margin; 1000 x, BF.
Fig. 2: ditto; 1000 x, DIC.
Fig. 3: Hairs of the ectal excipulum; SEM picture, 1500 x.
Fig. 4: Some hairs, showing "hooks"; SEM picture, 5400 x.
Fig. 5: A group of apothecia as seen under the stereo-microscope; 47 x.
Fig. 6: Two asci, one with ascospores. Note the apical apparatus and the oil drops in the spores (arrows); 1000 x, DIC.
(photos: W.R. Arendholz)

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Holotypus. - In superficiebus ambabus foliorum emortuorum angiospermorum, Bomdila, West Kameng, Arunachal Pradesh, August 23, 1981, Raghunandan Sharma, 17833 (PAN).

Apothecia gregarious, superficial, soft whitish, sessile, plane to convex, up to 1 mm in diameter, minutely downy. Hymenium whitish, drying umber to ochraceous.

Ectal excipulum of textura prismatica, cells hyaline, thin-walled, up to 11 x 5 µm, the outermost cells drawn out into smooth, thin-walled hairs. Hairs strongly curved at the tips, like a hook, simple to forked at the apices, the forked apices may point upwards or curve downwards, up to 30 x 3 µm long.

Medullary excipulum of textura intricata, hyphae hyaline, thin-walled, septate, compactly arranged, cells up to 14 x 2 µm.

Asci 8-spored, J+, 55-65 x 7-7.5 µm, clavate-cylindric, apex round, base flat, arising from croziers.

Ascospores hyaline, ellipsoid, biguttulate, 8.5-12 x 2-3 µm, obliquely uniseriate to irregularly biseriate.

Paraphyses hyaline, filiform, branched, septate, up to 3 µm wide at the top, projecting up to 15 µm beyond the tips of the asci.

Etymology of the specific epithet. - Refers to the hooked hairs.

Habitat. - On both sides of dead fallen angiosperm leaves.

Type locality. - Bomdila, West Kameng, Arunachal Pradesh.

Holotype. - August 23, 1981, Raghunandan Sharma, PAN 17833, isotype in the junior author's personal herbarium (W.R.A. 1984-1024).

NOTES. - With some hesitation we classify this specimen in HYALOSCYPHA, although many characters (excipulum, basic hair character, etc.) speak well for this classification, except for the rarely irregularly branched tips of the hairs. This character recalls some affinity with the hair character of DENOROTRICHOSCYPHA (SVRCEK 1977). Possibly both these genera can be united, if we understood HYALOSCYPHA better. On the other hand, the hooked tips suggest a classification with HAMATOCANTHOSCYPHA (SVRCEK 1977; UNCINIELLA K. et L. HOLM 1977), but in this genus the excipulum is more of a textura angularis and the base of the hairs is not swollen.

HYALOSCYPHA HIMALAYENSIS Arendholz & R. Sharma sp. nov.
FIGS. Plate 3: Fig. 1-4. 6-6a, Plate 4: Fig. 1-6

Apothecia gregaria, mollia, sessilia, cupulata, ad 0.5 mm diam.. Receptaculum album, in sicco bubalinum, minute villosum, pili varie curvati ad circinati, ad 11 x 2 µm. Hymenium concolorum cum receptaculo. Excipulum ectalum ex textura prismatica ad textura angularis. Asci octospori, 15-25 x 5-6 µm, clavati, apex rotundus, poro jodo caerulescente. Ascosporae hyalinae, fusoideae, 5.5-8 x 0.8-1.5-(2.0) µm, in gelatina inclusae, irregulariter biseriatae. Paraphyses hyalinae, simplices, septatae, ad 2.5 µm latae, ascos parce superantes.
Holotypus. - In superficiebus ambabus foloiorum emortuorum caducorumque, Bunakha apud Chimakothi, Bhutan, July 29, 1981, Raghunandan Sharma, 17694 (PAN).

Apothecia gregarious, soft, sessile, cupulate, white,drying buff, up to 0.5 mm in diam., minutely downy. Ectal excipulum of textura prismatica to textura angularis, up to 10 µm thick.

The brick shaped, thin-walled excipular cells (up to 7 x 2 µm) are drawn out, especially at the margin, into small, variously curved to circinate, smooth and thin-walled hairs, up to 11 x 2-(3) µm long.

Medullary excipulum a rather loose textura intricata.

Asci 8-spored, J+, 15-20-(25) x 5-6 µm, clavate, apex round, base small, flat.

Ascospores hyaline, fusoid, 5.5-8 x 0.8-1.5-(2.0) µm, irregularly biseriate; spores embedded in a gelatinous sheath 0.8-1.3 µm thick, which is particularly visible in free ascospores.

Paraphyses filiform, hyaline, simple, septate, up to 2.5 µm wide at the top, slightly projecting beyond the tips of the asci.

Etymology of the specific epithet. - Refers to the locality, where the specimen was collected.

Habitat. - On both surfaces of dead fallen angiosperm leaves.

Type locality. - Bunakha, near Chimakothi, Bhutan.

Holotype. - July 29, 1981, Raghunandan Sharma, PAN 17694; isotype in the junior author's personal herbarium (W.R.A. 1984-1026); paratype Chimakothi, July 27, 1981, Raghunandan Sharma, PAN 17653; W.R.A. 1984-1027.

NOTES. - Hyaloscypha himalayensis somewhat resembles Hyaloscypha lachnobrachya (Desm.) Nannf.; the type of that was studied by one of us in a previous study (ARENDHOLZ 1979). This species grows on dead leaves of deciduous trees (e.g. Acer, Betula, Quercus), too, but has asci nearly twice as large (30-40 x 5-6 µm) with four ascospores (9-13 x 1.5-2.5 µm), which have no gelatinous sheath.

There is another collection (PAN 17653, cf. plate 4, Fig. 1-5) which has somewhat larger asci (up to 25 µm) and the ascospores are sometimes up to 2.0 broad. The hymenium is more or less flat rather than convex as in the type collection. Otherwise the remaining characters are identical (incl. the gelatinous sheath of the ascospores), so that we consider both these specimens conspecific. A statistical analysis (F- and t-test) corroborates this decision.

Following is a key to determine the species of HYALOSCYPHA known from the Indian subcontinent:

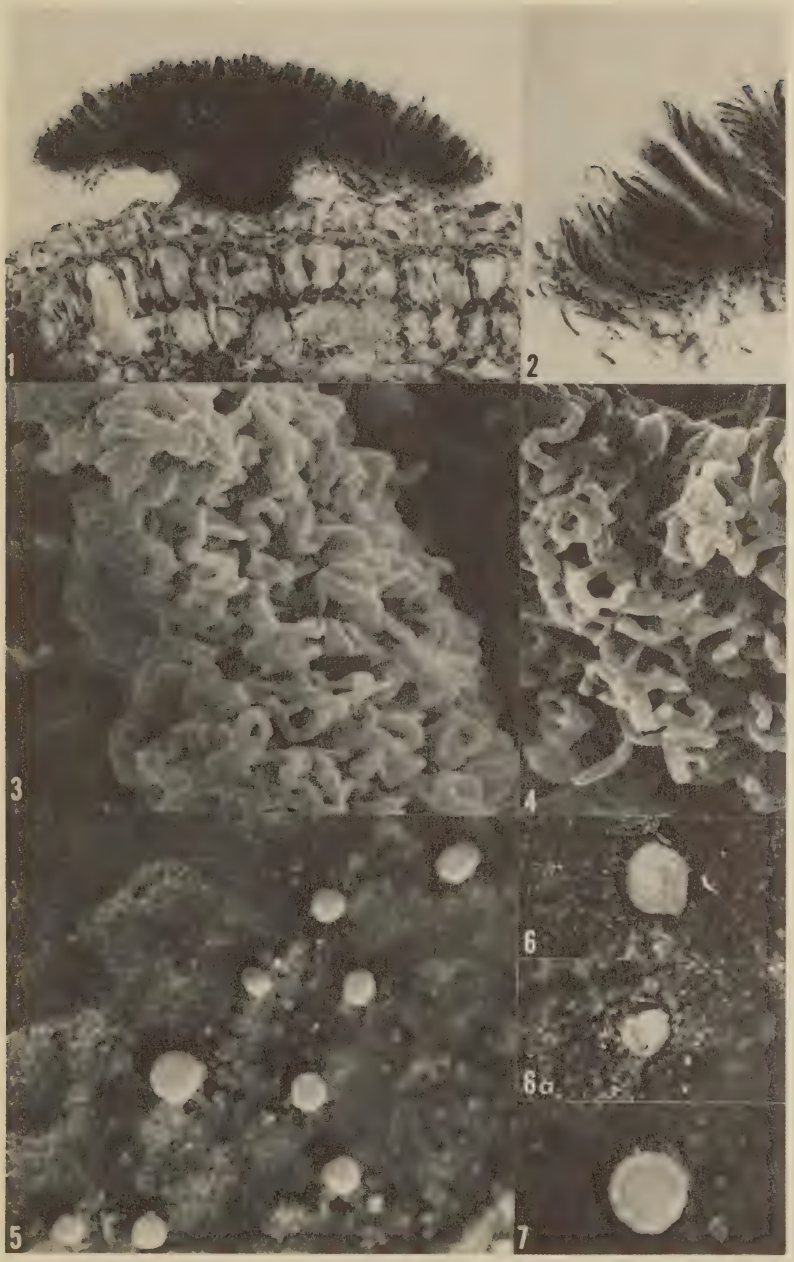
1.	Apothecia growing on fallen leaves of deciduous trees	2
1*.	Apothecia not growing on fallen leaves of deciduous trees	3
2.	Asci >30 µm, ascospores >8 µm	H. uncinata
2*.	Asci <30 µm, ascospores <8 µm	H. himalayensis
3.	Apothecia growing on dead fallen grass leaves, asci J-	H. pusilla

(Cf. ARENDHOLZ & R. SHARMA 1983)

Plate 3

HYALOSCYPHA HIMALAYENSIS Arendholz & R. Sharma sp. nov.; PAN 17694: Fig. 1-4, 6-6a; PAN 17833: Fig. 5, 7.

Fig. 1: LS showing apothecium; 400 x, BF.
Fig. 2: LS showing margin and part of the hymenium; 1000 x DIC.
Fig. 3: Part of the margin; SEM picture, 2800 x.
Fig. 4: Part of the ectal excipulum; SEM picture, 2800 x.
Fig. 5: Group of apothecia seen under the stereomicroscope; 40 x.
Fig. 6, 6a: Two apothecia, top view, seen under the stereomicroscope; 63 x, 40 x, respectively.
Fig. 7: Apothecium, top view, seen under the stereomicroscope; 63 x.
(photos: W.R. Arendholz)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3*. Apothecia not growing on dead fallen grass leaves, asci J+ or J-

4. Apothecia up to 0.15 mm in diam., asci J+, ascospores ± allantoid, 5.5-11.5 x 1.5-2.5 µm — H. parvula (Cf. ARENDHOLZ & R. SHARMA 1983)

4*. Apothecia up to 0.68 mm in diam., asci J-, ascospores elliptic-fusiform, 6-9 x 1.6-2.6 µm — H. cf. stevensonii (Cf. THIND & SAINI 1967)

DENDROTRICHOSCYPHA TETRASPORA Arendholz & R. Sharma sp. nov.

FIGS.: Plate 5: Fig. 1-7

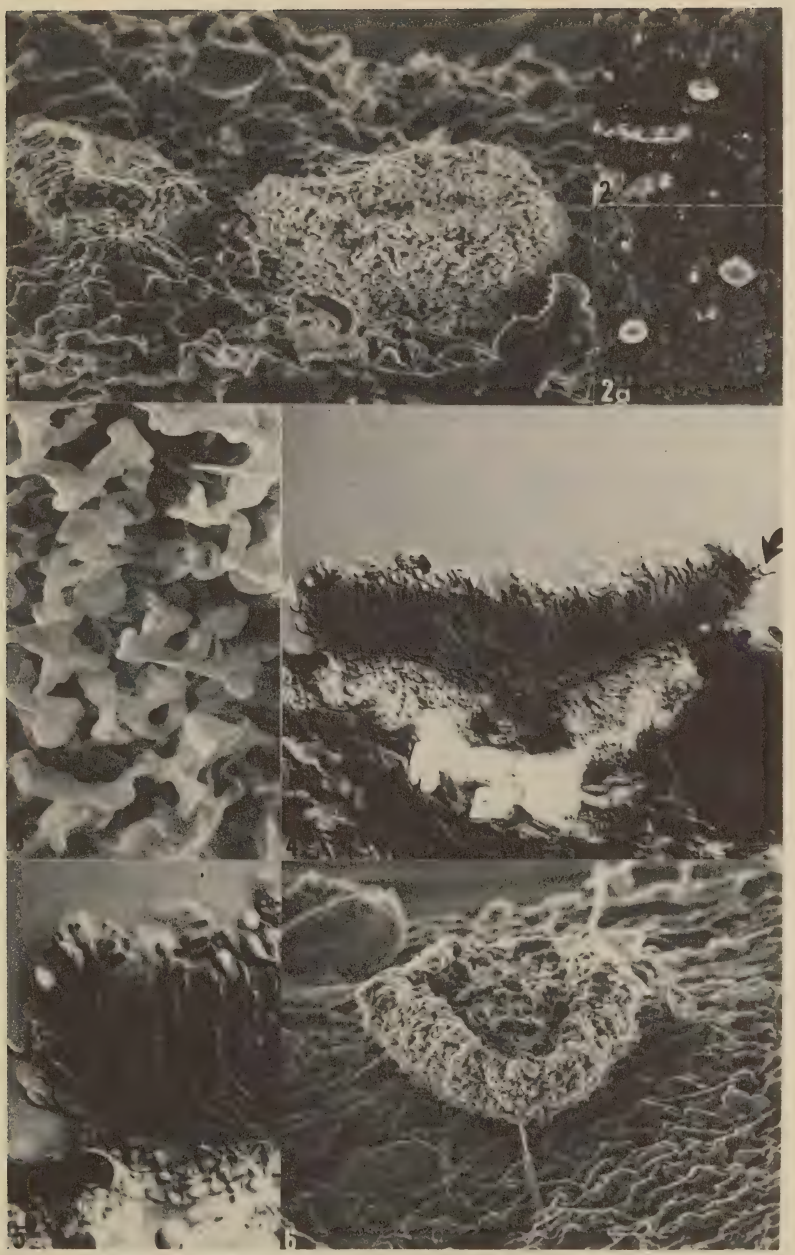
Apothecia gregaria, sessilia, cupulata ad plana, ad 1 mm diam. Receptaculum album, in sicco ± bubalinum, subtiliter villosum, pili curvati, uncinati, ad 15 x 3 µm. Excipulum ectalum ex textura prismatica, excipulum medullatum ex textura intricata. Asci tetraspori, e uncis nati, 23-30 x 5 - 5.5 µm, clavati-cylindrici, poro jodo caerulescente. Ascosporae hyalinae, 5.5-9 x 1.5-2 µm, elongatae ellipsoideae, biguttulatae, eseptatae, bilatae, ascos ad 10 µm superantes.

Holotypus. - In foliis caducis monocotyledonis, 5 km a Jamiri ad Nachephu, West Kameng, Arunachal Pradesh, September 12, 1981, R. Sharma, 24049 (PAN).

Plate 4

HYALOSCYPHA HIMALAYENSIS Arendholz & R. Sharma sp. nov.; PAN 17653: Fig. 1-5; PAN 17694: Fig. 6.

Fig. 1: Two apothecia, SEM picture, 400 x.
Fig. 2, 2a: Apothecia seen under the stereomicroscope, side view, top view, respectively; 63 x.
Fig. 3: Hairs of the ectal excipulum; SEM picture, 2800 x.
Fig. 4: LS of an apothecium, note the hooked hairs (arrows); 400 x, DIC.
Fig. 5: LS; part of the margin, excipulum and hymenium; 1000 x, DIC.
Fig. 6: Apothecium; SEM picture, 400 x.
(photos: W.R. Arendholz)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Apothecia scattered, sessile, shallow cupulate to plane, white, drying whitish buff, up to 1 mm in diameter, minutely downy.

Ectal excipulum of textura prismatica, the brick-shaped, thin-walled, hyaline excipular cells up to 8 x 3 µm. Hairs thin-walled, smooth, irregularly branched, hooked, especially at the margin, up to 15 x 3 µm.

Medullary excipulum of textura intricata.

Asci 4-spored, J+, 23-30 x 5-5.5 µm, clavate-cylindric, apex round, base small, stem-like, arising from croziers.

Ascospores hyaline, elongate-ellipsoid, 5.5-9 x 1.5-2 µm, biguttulate, non-septate, biseriate.

Paraphyses filiform, simple, septate, up to 1.5 µm wide at the top, projecting up to 10 µm beyond the tips of the asci.

Etymology of the specific epithet. - Refers to the number of the ascospores in the asci.

Habitat. - On fallen monocotyledonous leaves.

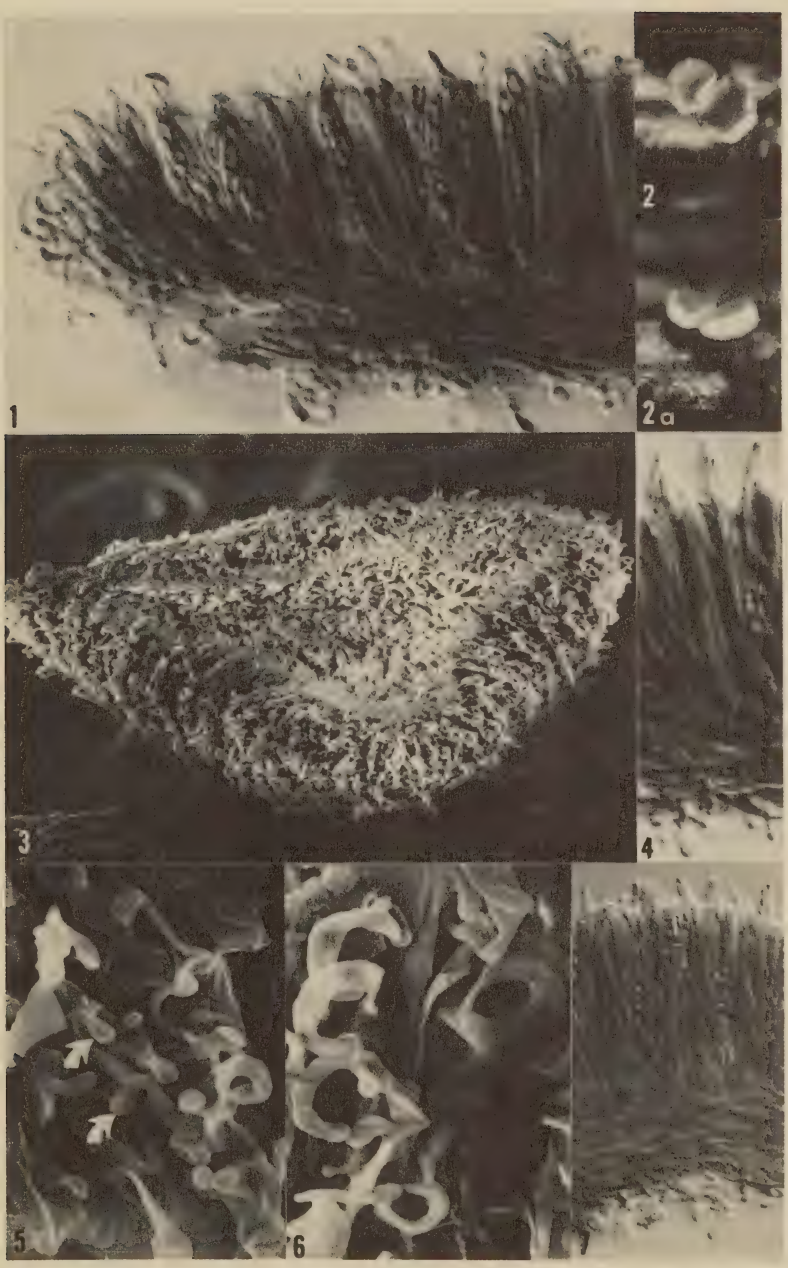
Type locality. - 5 km from Jamiri towards Nachephu, West Kameng, Arunachal Pradesh.

Holotype. - September 12, 1981, Raghunandan Sharma, PAN 24049; paratypes on dead and decaying angiosperm stem, Jamiri, West Kameng, Arunachal Pradesh, September 12, 1981, Raghunandan Sharma, PAN 24043, and in the junior author's personal herbarium (W.R.A. 1984-1022, 1984-1023).

Plate 5

DENDROTRICHOSCYPHA TETRASPORA Arendholz & R. Sharma sp. nov.; PAN 24049.

Fig. 1: LS showing margin with hooked hairs, part of the ectal excipulum and hymenium; 1000 x, DIC.
Fig. 2; 2a: Apothecia seen under the stereomicroscope, top view, side view, respectively; 47 x.
Fig. 3: Apothecium showing downy excipulum; SEM picture, 400 x.
Fig. 4: LS showing part of the hymenium with some lanceolate paraphyses; 1000 x, DIC.
Fig. 5; 6: Hairs of the ectal excipulum and at the margin, note the branches of the hairs (arrows); SEM pictures, 4000 x.
Fig. 7: LS showing part of the hymenium, of the excipulum and some hairs; 630 x, DIC.
(photos: W.R. Arendholz)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NOTES. - Dendrotrichoscypha tetraspora shows some resemblance to Mollisina uncinata Arendholz & R. Sharma (ARENDHOLZ & R. SHARMA 1984), but in this species the apothecia are smaller (0.4 mm in diam.), and the asci and ascospores are larger (40-55 x 7-7.5, 12-16.5 x 1.5-2 µm, respectively). Whether the Chalara anamorph belongs to the Mollisina species or whether it is a parasitic hyphomycete of the Chalara-type "which is not unfrequently found in small Discomycetes" (HOLM 1977, p. 18) has to be proven by culture studies.

Our species differs from the generic type (Dendrotrichoscypha acanthopila Svrcek) by its larger apothecia, the smaller, J+ asci and the four, biguttulate ascospores.

As we stated earlier (ARENDHOLZ & R. SHARMA 1984), possibly DENDROTRICHOSCYPHA and MOLLISINA can be united, for TEM studies by one of us (ARENDHOLZ in preparation) reveal, that the hyphal processes of MOLLISINA do have a cell-lumen, as already indicated by light microscopy studies (cf. ARENDHOLZ & R. SHARMA 1984, p. 658 and p. 661 figs. 5a and 5b).

DEBARYOSCYPHUS ARENDHOLZ & R. SHARMA gen. nov.

Genus familiae Leotiaceae (Helotiales), apothecia breviter stipitata, stipes basi ater. Receptaculum minute pubescens, pili longi, hyalini, laeves et leptodermi, e- ad uniseptati, ad apicem curvati. Excipulum ectalum ex textura porrecta ad textura intricata. Excipulum medullatum ex textura intricata. Asci octospori, e uncis nati, clavati-cylindrici, poro jodo caerulescente. Ascosporea hyalinae, continuae, ellipsoideae, parvae. Paraphyses filiformes, ascos parce superantes.

Species typica generis: DEBARYOSCYPHUS MELANOBASIS Arendholz & R. Sharma sp. nov.

Etymology of the generic name. - In honour of the great German mycologist (and botanist) Anton de Bary (1831-1888).

DEBARYOSCYPHUS MELANOBASIS Arendholz & R. Sharma sp. nov.

FIGS. Plate 6: Fig. 1-6

Apothecia dense gregaria, mollia, breviter stipitata, stipes ad 0.2 x 0.1 mm, basis ater; cupulata, ad 1 mm diam. et ad 0.5 mm alta. Receptaculum aureum, in sicco bubalinum ad ochraceum, minute pubescens, pili longi, hyalini, e- ad

uniseptati, ad apicem curvati, ad 20 x 5 µm. Hymenium concolorum cum receptaculo. Asci octospori, 30-40 x 5-6 µm, clavati-cylindrici, apex rotundus, poro jodo caerulescente. Ascosporae hyalinae, ellipsoideae ad late ellipsoideae, biguttulatae, 3.5-6.5 x 1.5-3 µm, uniseriatae ad irregulariter biseriatae. Paraphyses filiformes, simplices, septatae, ad 2 µm latae, ascos parce superantes.
Holotypus. - In cortice angiospermo, Nawephu, Thimphu, Bhutan, September 26, 1980, R. Sharma, 17590 (PAN).

Apothecia densely gregarious, soft, stalked, stipe up to 0.2 x 0.1 mm, black at the base; cupulate, up to 1 mm in diameter and up to 0.5 mm in total height. Receptacle bright yellow, drying buff to ochraceous, minutely downy, hairs hyaline, smooth and thin-walled, up to 20 x 5 µm, one- to two-celled, curved at the apices.

Ectal excipulum of textura porrecta to textura intricata.

Medullary excipulum of textura intricata.

Asci 8-spored, J+, 30-40 x 5-6 µm, clavate cylindric, apex round, base small, flat.

Ascospores hyaline, ellipsoid to broadly ellipsoid, biguttulate, 3.5-6.5 x 1.5-3 µm, uniseriate to irregularly biseriate.

Paraphyses filiform, simple, septate, up to 2 µm wide at the top, slightly projecting beyond the tips of the asci.

Etymology of the specific epithet. - Refers to the dark base of the stipe.

Habitat. - On bark of some angiosperm.

Type locality. - Nawephu, Thimphu, Bhutan.

Holotype. - September 26, 1980, Raghunandan Sharma, PAN 17590; isotype in the junior author's personal herbarium (W.R.A. 1984-1028).

NOTES. - Debaryoscyphus melanobasis is a very interesting species. Nearly one half of the stipe is built up of dark-walled hyphae, but there is neither a sclerotium nor a substratal stroma. The structure of the ectal and medullary excipulum recalls affinities with HYMENOSCYPHUS, but the hooked hairs, which are not swollen or expanded at their bases are unknown in this genus. On the other hand the anatomical characters of the excipulum do not agree with those in HAMATOCANTHOSCYPHA Svrcek (hooked hairs: = UNCINIELLA Holm & Holm) or HYALOSCYPHA Boud. (straight and ± pointed hairs).

A classification in BISPORELLA or CROCICREAS is out of place, too, although in these genera we find hairs in some species, but these have an ectal excipulum of textura oblita, i.e. the hyphae are embedded in a gelatinous matrix. Due to the above diagnostic characters the erection of the new genus is justified.

UNGUICULELLA EUROTIOIDES (Karst.) Nannf. Trans. Brit. Mycol. Soc. 26: 194 (1936)

FIGS. Plate 7: Fig. 1-6

Apothecia gregarious, small, soft, shallow cupulate, subsessile, up to 0.3 mm in diameter. Receptacle light yellow, drying pale luteous to ochraceous, margin thick inrolled, deep cupulate on drying, minutely downy. Hymenium yellow, turning bright yellow, drying ± ochraceous.

Ectal excipulum of textura intricata to textura angularis, cells up to 5 x 4 µm, outermost cells drawn out into hairs, hairs tapering to fine point, strongly hooked at the apices, up to 30 x 4 µm.

Medullary excipulum of textura intricata, hyaphae septate, up to 3 µm wide.

Asci 8-spored, J-, 35-45 x 4-5 µm, clavate-cylindric, apex round, base stem-like, arising from croziers.

Ascospores hyaline, ellipsoid biguttulate, 4-6 x 1.5-2.5 µm, uniseriate to irregularly biseriate.

Plate 6

DEBARYOSCYPHUS MELANOBASIS Arendholz & R. Sharma sp. nov. PAN 17590.

Fig. 1: LS through an apothecium, note the dark stipe base; 160 x, BF.
Fig. 2: Apothecium showing downy excipulum; SEM picture, 280 x.
Fig. 3: Hairs of the excipulum; SEM picture, 3500 x.
Fig. 4: Some apothecia seen under the stereomicroscope, side view; 47 x.
Fig. 5: LS showing part of the margo, excipulum and hymenium, note the hooked hairs (arrows); 400 x, DIC.
Fig. 6: LS, stipe base showing dark-walled hyphae; 1000 x, BF. (photos: W.R. Arendholz)

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Paraphyses pale yellow in groups, hyaline individually, filiform, wider at the base (up to 3 µm), strongly hooked at the tips, slightly projecting beyond the tips of the asci.

Habitat. - On dead, shruby angiosperm stem.

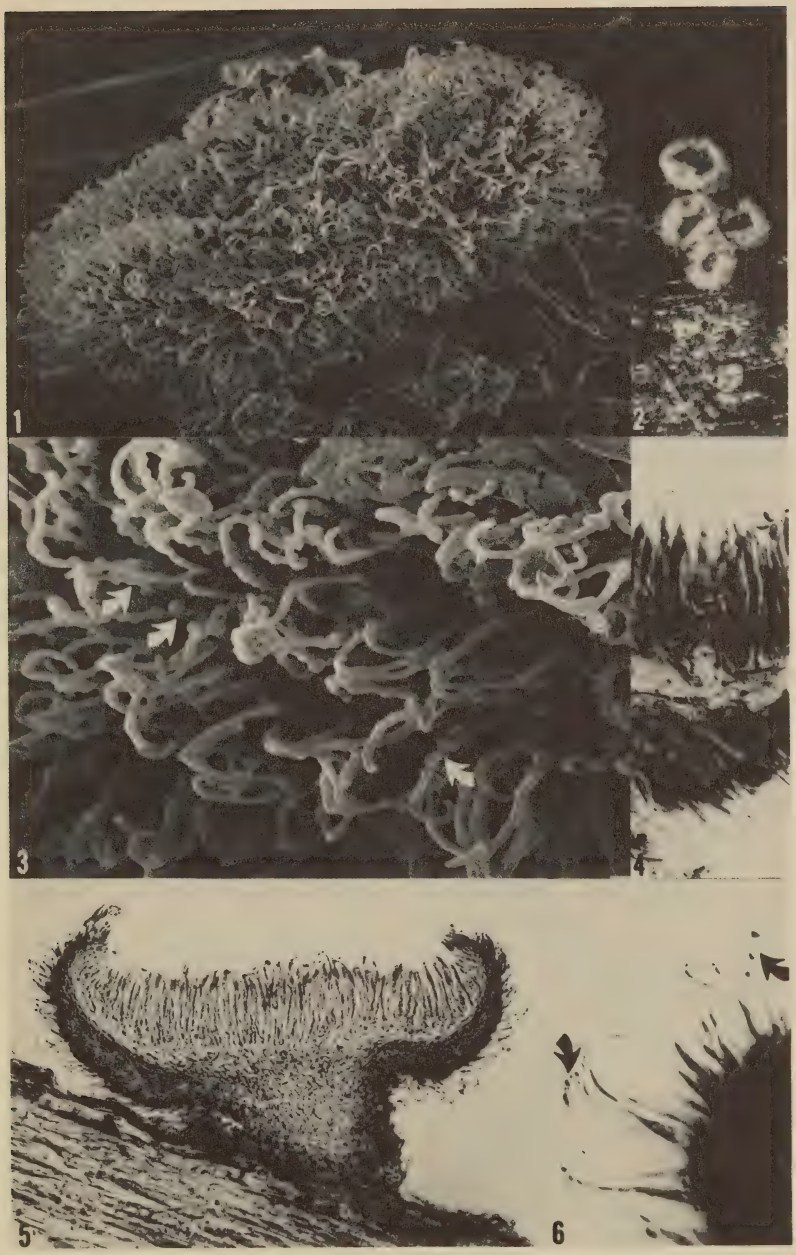
Specimens examined. - 10 km from Bomdila towards Tawang, West Kameng, Arunachal Pradesh, August 27, 1981, Raghunandan Sharma, PAN 17916; part of this collection is also deposited in the junior author's personal herbarium and at NYS. Syntype of Peziza eurotioides Karst., Fungi fenn. 652 (CUP-D 4207).

NOTES. - Our specimen seems to be identical with UNGUICULELLA EUROTIOIDES (Karst.) Nannf., although there are some differences between the Indian and the type specimen (KARSTEN 1869): In the Indian one the hooked hairs show bubbly swellings, both in the light microscope and in the scanning electron microscope. These swellings are absent in the type. Furthermore the walls of the asci of the type are somewhat thicker, but otherwise both the specimens match well with each other.

Plate 7

UNGUICULELLA EUROTIOIDES (Karst.) Nannf.; PAN 17916; Fig. 1-4, 6; Fungi fenn. 652 (CUP-D 4207): Fig. 5, syntype.

Fig. 1: Apothecium showing hairy excipulum, SEM picture; 400 x.
Fig. 2: A group of apothecia seen under the stereomicroscope, 47 x.
Fig. 3: Hairs of the ectalexcipulum, note the "bubbles" on the hairs (arrows); SEM picture, 1500 x.
Fig. 4: LS showing part of the hymenium and excipulum, note the hooked paraphyses (arrow); 630 x, DIC.
Fig. 6: LS, margo with hairs, note the "bubbles" at the hairs (arrow) as shown in the SEM picture above (Fig. 4); 1000 x, DIC.
Fig. 5: LS through an apothecium; 250 x, BF.
(photos: W.R. Arendholz)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ACKNOWLEDGEMENTS

The first and the third author are thankful to the Department of Science and Technology for the financial help. The junior author is pleased to acknowledge the valuable comments of Prof. Dr. R.P. Korf, Cornell University and Dr. J. H. Haines, New York State Museum, Albany. Furthermore he is grateful to Mrs. E. Miesel, who typed the camera-ready manuscript in a reliable manner.

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MYCOTAXON

Vol. XXV, No. 1, pp. 141-145 January-March 1986

A CORRECTED AUTHORS INDEX FOR A BIBLIOGRAPHIC ACCOUNT OF EXSICCATAE CONTAINING FUNGI

Donald H. Pfister
Harvard University Herbaria
Cambridge, Massachusetts

The index to authors of exsiccatae included in an article published earlier in this journal (Mycotaxon 23: 1-139. 1985) contains incorrect page numbers which resulted from a repagination of the final version. Though the index can be used simply by adding "5" to page numbers as printed it has seemed desirable to set the record straight by providing a proper index. A copy of this index is also available upon request from the author.

Allescher, Andreas 30
Andres, Heinrich 21
Annenkov, Nicolas Ivanovich 124
Arthur, Joseph Charles 114
Ayres, Philip Burnard 8, 78, 125
Baenitz, Karl Gabriel 63
Bail, Theodor 135
Baglietto, Francesco 22
Baker, Charles Fuller 43, 132
Balansa, Benedict Benjamin 121
Bang, Miguel 134
Barla, Joseph Hieronymus Jean Baptiste 131
Bartling, Friedrich Gottlieb 118
Bartholomew, Elam 32, 89
Baumgartner, Julius 71
Bavoux, Eugène-Vital 124
Baxter, William 109, 125
Bellynck, August 12
Bergman, Herbert Floyd 90
Berkeley, Miles Joseph 8
Berlese, Augusto Napoleone 126
Billot, Paul Constant 124
Bitancourt, Agesilau Antonio 86
Bonar, Lee 8
Bondartsev, Apollinaris Semenovich 51
Bondarzew, Apollinaris Semenovich 51
Bontea, Vera 62
Brândzǎ, Marcel Alex 87
Brenkle, Jacob Frederick 34
Bresadola, Giacomo 121
Briosi, Giovanni 69
Brick, Carl 53
Brinkmann, Wilhelm 118
Brockmüller, Hans Joachim Heinrich 74
Bubák, Frantisek 41
Bucholtz, Fedor Vladimirovic 51, 59

Buia, Alexandru 27
Burlingham, Gertrude Simons 131
Calkins, William Wirt 125
Carleton, Mark Alfred 114
Cavara, Fridiano 42, 69
Cesati, Vincenzo de 22
Chodat, Robert Hippolyte 129
Ciferri, Rafael 77
Clements, Edith Gertrude Schwartz 11
Clements, Frederick 11
Comes, I. 27
Constantinescu, Ovidiu 62
Cook, Orator Fuller 9
Cooke, Mordecai Cubitt 28, 31, 91, 125
Cooke, William Bridge 76, 106
Costescu, M. 27
Crandall, Charles Spencer 123
Cummings, Clara Eaton 132
Cummins, George Baker 78
Davis, John Jefferson 127
Delise, Dominic François 124
Desmazières, Jean Baptiste Henri Joseph 101
Dickson, James 10, 130
Doassans, Jacques Émile 9
Dutertre, E. 121
Earle, Franklin Sumner 21
Ehrhart, Jacob Friedrich 93, 133
Eichhorn, Eugen 116
Ekart, Tobias Phillipp 123
Ellis, Job Bicknell 32, 88, 126
Ene, Il. 27
Eriksson, Jakob 41, 135
Everhart, Benjamin Matlack 32, 88
Fautrey, François 56, 130
Fiedler, Carl Friedrich Bernard 120
Fischer, George William 59
Fries, Elias Magnus 108
Fristedt, Robert Fredric 113
Fuckel, Leopold [Karl Wilhelm Gottlieb] 45
Funck, Heinrich Christian 12
Gandoger, Michel 124
Garrett, Albert Osbun 58
Glodeanu, G. 27
Grant, John Marshall 127
Griffiths, David 118
Gruff, Susan C. 21
Guba, Emil Frederick 105
Guichard, Albert 124
Guichard, Paul 124
Hamburg, Knut Herman Rudolf 130
Hampe, Georg Ernst Ludwig 118
Harkey-Smith, Charles E. 135
Hartmann, Emanuel Friedrich 98
Heim, Roger 12
Hennings, Paul 123, 131
Henriques, Julio Angusto 26
Héribaud-Joseph, Frère [Jean Baptiste Caumel] 122
Herpell, Gustav Jacob 106
Herter, Wilhelm Gustav Franz 100
Hilitzer, Alfred 10
Hintikka, Toivo Juho 90, 120
Hiratsuka, Naohide 134
Holl, C. Friedrich 18
Holway, Edward Willet Dorland 105, 114
Hoppe, David Heinrich 125
Hostmann, F. W. 134
Hume, Hardrada Harold 44
Jaap, Otto 53, 87, 121
Jack, Joseph Bernhard 73
Jaczewski, Arthur Louis de 50
Jenkins, Anna Eliza 86
Jenner, Th. 25
Kabát, Josef E. Manuel 41

Kappler, August 134
Kari, Lauri Elrikki 36
Karsten, Peter Adolf 38, 44 91, 92
Kavina, Karel 10
Keissler, Karl von (Ritter) 71
Kellerman, William Ashbrook 57, 70, 91
Klotzsch, Johann Friedrich 66
Kmet, Andreas 27
Kneiff, Friedrich Gotthard 98
Kochman, Józef 84, 116
Komarov, Vladimer Leontj Wevic 50
Korf, Richard Paul 21
Krieger, Karl Wilhelm 52, 107
Kunze, Gustav 18
Kunze, Johannes 54
Lagerberg, Karl Erik Torsten 108
Lasch, Wilhelm Gottfried 63
Leeuwen, Willem Marius Docters van 135
Leiner, Ludwig 73
Leppik, Elmar Emil 35
Libert, Marie Anne 95
Linder, David Hunt 16
Linhart, Gyömgy 40
Lindroth, Johan Ivar 80
Liro, Johan Ivar 80
Litschauer, Viktor 55, 58
Lohwag, Heinrich 55
Lundell, Seth 37
Lundquist, Nils 40
McMillan, Phyllis Gardner 8
Maire, René 25, 78
Malbranche, Alexandra François 123
Mannagetta und Lerehenau, Gunther (Ritter) Beck von 71
Marchal, Elie 123, 134
Marguery, Felix 25
Migula, Emil Friedrich August Walter 71
Miller, Vera Mentzer 8
Minkevicius, Antanas 26
Minkyavichyus, Antanas 26
Mougeot, Jean Antoine 110
Mougeot, Jean Baptiste 110
Muenscher, Walter Conrad 89
Namyslowski, Bolesław 83
Nannfeldt, Johann Axel Frithiof 37
Nannizzi, Arturo 69
Neger, Franz Wilhelm 28
Negrean, Gavril 62
Nees von Esenbeck, Theodor Friedrich Ludwig 129
Nevodovskii, G. 59, 60
Nestler, Christian Gottfried 110
Notaris, Giuseppe de 22
Opiz, Phillip Maximilian 26, 129
Oudemans, Cornelis Antoon Jan Abraham 44, 65
Paillot, Justin 124
Parks, Harold E. 8
Parmasto, Erast 79
Paun, Marin 27
Pazchke, Franz Otto 66
Patouillard, Narcisse Theophile 9
Petrak, Franz 25, 28, 35, 71, 79, 80, 127
Phillips, William 22
Pilát, Albert 32
Plowright, Charles Bagge 109
Poeverlein, Herman 116, 128
Pollacci, Gino 42, 69
Posch, Karl 127
Rabenhorst, Gottlob Ludwig 66, 130, 131
Raciborski, Maryjan 11, 83
Ravenel, Henry William 28, 32
Rechinger, Karl 71
Rehm, Heinrich 6, 132

Reichardt, Heinrich Wilhelm 133
Rick, Johann 29
Roberts, Herbert Fuller 130
Roivainen, Heikki 80
Romell, Lars 37, 127
Roth, Albrecht Wilhelm 129
Roumeguère, Casimir 56, 110, 121, 122, 126, 128
Saccardo, Domenico 82
Saccardo, Francesco 126
Saccardo, Pier Andrea 86, 134
Savulescu, Traian 62
Schaeffer, Julius 106
Schleicher, Johann Christoff 93
Schenk, Bernard 107
Schimper, Wilhelm Philipp 110
Schmidt, Johann Carl 18
Schnabl, Johann Nepomuk 30
Schneider, Wilhelm Gottlieb 64
Schrader, Heinrich Adolph 135
Schröter, Joseph 92
Schultz-Bipontinus, Friedrich Wilhelm 63
Schultz, Friedrich Wilhelm 124
Schulz, Hermann 88, 133
Seaver, Fred Jay 7, 90
Serebrianikow, J. 81
Seymour, Arthur Bliss 21, 105
Shaw, Charles Gardner 106
Shear, Cornelius Lott 32, 88
Sherwood, Martha Allen 92
Siemaszko, Wincenty 30, 45
Smarods, Julius 42
Smith, Charles Leonard 9
Sommerfelt, Søren Christian 101
Spegazzini, Carlos 17, 68, 125
Solhelm, Wilhelm Gerhard 77
Sredinski, Nicolai C. 61
Stitzenberger, Ernst 73
Swingle, Walter Tennyson 70
Sydow, Hans 32, 81
Sydow, Paul 81, 83, 93, 115, 117
Sylven, Nils Olaf Valdemar 108
Szatala, Odon 71
Szulezewski, A. 60
Tavares, Isabelle Irene 8
Tempère, Johannes Albert 21
Thaxter, Roland 16
Theissen, Ferdinand 16
Therry, Joseph Jean 123
Thümen, Felix Karl Albert Ernst Joachim de 29, 60, 85, 132
Torrend, Camille 55
Tranzschel, Waldemar Andrejevic 50, 84
Traverso, Giovanni Battista 126
Trotter, Alexandro 121
Ule, Ernst Heinrich Georg 79, 128
Underwood, Lucien Marcus 9, 70
Vanca, Ana 27
Vanky, Kálmán 116
Vasudeva, Raghu Nath Sahai 60
Vestergren, Jacob Tycho 75
Vill, August 30
Vize, John Edward 31, 74, 75
Wagner, Albert 11
Wagner, Hermann 11
Wallys, Antoine Charles François 68
Wann, Frank Burkett 89
Wartmann, Friedrich Bernhard 107
Waterston, John MacLauren 7
Weese, Josef 24
Weiss, Johann Evangelist 64
Welwitsch, Friedrich Martin Josef 16

Westendorf, Gérard Daniel 68
Whetzel, Herbert Hice 7
Wilson, Guy West 7
Winter, Georg 40, 54, 66, 107
Wróblewski, Anton 45
Zahlbruckner, Alexander 71
Zhukovoi, C. P. 60
Zillig, Herman 117, 136

MYCOTAXON

Vol. XXV, No. 1, pp. 147-152 January-March 1986

The New Species Dekkera naardenensis, Teleomorph of Brettanomyces naardenensis

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Summary

Dekkera naardenensis sp. nov. is described to accommodate the ascogenous state (teleomorph) of Brettanomyces naardenensis Kolfschoten et Yarrow. ATCC 22075, the type culture of B. naardenensis which was isolated from aerated lemonade in the Netherlands, is designated as the type. The vitamin-enriched Endothia complete agar medium with a pH of 4-5 is most effective for inducing ascospore formation.

Brettanomyces naardenensis Kolfschoten et Yarrow (1970) was established on the basis of twelve strains isolated from soft drinks with a pH ranging between 2.6-3.2. The strain CBS 6042 (=ATCC 22075) isolated from aerated lemonade with a pH of 2.8 in the Netherlands is the type culture. It was distinguished from all the accepted species by assimilating soluble starch. Ascospores were not observed in any of the strains on either the normal sporulating media or media supplemented with vitamins.

In his identification key to the species of Brettanomyces Kofferath et van Laer, van der Walt (1984) separates the species from B. anomalus and B. claussenii by not fermenting lactose, from B. custersii by not assimilating lactose, from B. intermedius by not using sucrose, from B. abstinens by assimilating trehalose, and from B. custersianus, B. lambicus and B. bruxellensis by assimilating cellobiose. According to Barnett et.al. (1983), G + C nuclear DNA for B. naardenensis is 42.2-43.4 mol %.

The genus Dekkera van der Walt (1964), characterized by hat-shaped, easily liberated ascospores, is the perfect state of Brettanomyces. Members of both genera produce large amounts of acetic acid through the incomplete oxybiontic dissimilation of carbohydrate and are characterized by a so-called "negative Pasteur effect" or "Custer effect", i.e., a stimulation of fermentation of molecular oxygen and acetoin (Scheffers, 1966; Scheffers & Wiken, 1969). Although the genus Dekkera and its anamorphic genus

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Brettanomyces appear morphologically and physiologically to be most closely related to the genus Hanseniaspora Zikes and its anamorphic genus Kloeckera Janke (van der Walt, 1963, 1970; Fiol & Billon-Grand, 1978), the presence of the coenzyme Q-9 system in the former two genera and the coenzyme Q-6 system in the latter two genera has excluded this possibility (Yamada et.al., 1980).

In our authentication of the yeast strains maintained in the American Type Culture Collection (ATCC), we have found for the first time ascospores in the cultures of B. naardenensis ATCC 22075 (type) and ATCC 56870 (=CBS 6040) grown on vitamin-enriched media with a pH ranging between 4-5. It has therefore revealed the fungus to be a new species of Dekkera which is described herein.

Dekkera naardenensis Jong et Lee, sp. nov.
Stat. anamorphosis: Brettanomyces naardenensis Kofferoth et Yarrow, 1970.

In extracto malti post dies 5 25°C, cellulae ellipsoidae vel cylindricae elongataeque, 1.5-3 X 3.5-25 µm singulae, binae vel catenatae. Cellulae longae pseudomycelii formantur. Sedimentum Aliquando annulus, insulae aut pellicula tenuis. Cultura acclivis, superficie limitata, media subfusca alba ad marginem, cerata et nitida vel opaca. Asci e cellulis diploidis transformatis oriuntur. Ascosporae pilleiformes ad 4 in quoque asco formantur. Ascosporae maturae ex ascis celeriter liberantur et inter se agglutinant. Fermentatio, crescentia in variis substantiis carbonaceis et alliae naturae monstrantur in Tabula 1.

Typus: ATCC 22075 in collectione American Type Culture Collection, Rockville, Maryland, USA.

Growth in malt extract: After 5 days at 25°C the cells are ellipsoidal to cylindrical, rarely ogival, 1.5-3 X 3.5-25 µm, reproducing by budding and occurring singly, in pairs or short chains. Pseudomycelium may be formed. A sediment is present. After 10 days the sediment is usually floccose and a thin ring or thin pellicle may be formed. The formation of a characteristic aroma is detectable.

Growth on malt agar: After 6 weeks at room temperature the streak culture is butyrous, brownish-cream, somewhat shiny to dull, smooth to somewhat pulvinate or somewhat raised. The margin is undulating or slightly lobate.

Growth on malt agar with 2% calcium carbonate: After 6 weeks at room temperature the streak culture is cream-colored to light brown, somewhat shiny to rather dull, smooth to pulvinate. The margin is undulating to lobate. Acid production is not very pronounced.

Dalmau plate culture on corn meal agar: A ramified pseudomycelium bearing few or no blastospores is produced. It is developed better under anaerobic conditions.

Physiological characteristics: Fermentation and growth on various carbon compounds, growth on nitrogen sources and some additional properties are summarized in Table 1.

Table 1. Physiological Test Results

	ATCC 22075	ATCC 56870
Growth in vitamin-free medium	-	-
Growth at 37 °C	-	-
Splitting of arbutin	-	-
Urea hydrolysis	-	-
Diazomium blue B reaction	-	-
Acetic acid production	+w	+
Starch formation	-	-
Fermentation of:		
Glucose	+	+
Galactose	-	-
Maltose	-	-
Sucrose	-	-
Lactose	-	-
Raffinose	-	-
Melibiose	-	-
Inulin	-	-
Cellobiose	D	-
Melezitose	-	-
Starch	-	-
Trehalose	D	D
α-Methyl-D-Glucoside	-	-
Assimilation of:		
Glucose	+	+
Galactose	+	+
L-Sorbose	-	-
Maltose	D	D
Sucrose	-	-
Cellobiose	+	+
Trehalose	+	+
Lactose	-	-
Melibiose	-	-
Raffinose	-	-
Melezitose	-	-
Inulin	-	-
Soluble starch	+	+
D-Xylose	+	+
L-Arabinose	-	-
D-Arabinose	-	+w
D-Ribose	-	-
L-Rhamnose	+	+
D-Glucosamine	-	-
Ethanol	+	+
Methanol	-	-
Erythritol	-	-
Glycerol	-	-

Table 1. (continued)

	ATCC 22075	ATCC 56870
Adonitol	D	D
Dulcitol	-	-
D-Mannitol	+	+
D-Sorbitol	+	+
α-methyl-D-glucoside	-	-
Salicin	D	D
Inositol	-	-
Lactic Acid	+	+
Citric Acid	-	-
Succinic acid	+	D
Valine	-	-
Glycine	-	-
Proline	-	+w
Arginine	-	-
KNO_3	-	-
NO_2	-	-
Ethylamine	+	+

Code in Table: (+) positive; (-) negative; (D) delayed for longer than 7 days; (+w) weak

Formation of ascospores: Vegetative cells are transformed directly into asci, producing one to four ascospores. The ascospores are hat-shaped and can be stained with the modified Schaeffer-Fuller malachite green or Ziehl Neelsen's carbol fuchsin (Figs. 1,2). Mature ascospores tend to agglutinate when liberated. The occurrence of ascospore formation in the cultures of ATCC 22075 and ATCC 56870 depends greatly on media which have been adequately

Figs. 1-2. Asci and ascospores of Dekkera naardenensis, stained with modified Shaeffer-Fuller malachite green. ca. X 2,000. 1. ATCC 22075 (Type). 2. ATCC 56870.

enriched with vitamins. Sporulation is best observed in cultures at room temperature after one week on ATCC medium 686 (Cote et al., 1984), referred to as Endothia complete medium (Puhalla & Anagnostakis, 1971), supplemented with a vitamin solution which contains 0.2 mg biotin, 40 mg calcium pantothenate, 0.2 mg folic acid, 200 mg inositol, 40 mg niacin, 20 mg p-aminobenzoic acid, 40 mg pyridoxine hydrochloride, 20 mg riboflavin and 100 mg thiamine in a liter of demineralized water and sterilized by filtration (van der Walt & van Kerken, 1960).

Since the designated type culture ATCC 22075 is the type culture of Brettanomyces naardenensis Kolfschoten et Yarrow, the new species Dekkera naardenensis Jong et Lee is the perfect state (teleomorph) of B. naardenensis. Four species, D. bruxellensis van der Walt (1964), D. intermedia van der Walt (1964), D. anomala M. Th. Smith et van Grinsven (1984) and D. claussenii Lee et Jong (1985), are now recognized in the genus Dekkera. D. naardenensis is distinguished from the above accepted species by it ability to utilize D-mannitol, D-xylose and soluble starch and by its inability to grow at 37°C.

Dekkera naardenensis displays a rather strict habitat specificity and has thus far only been isolated from soda water and soft drinks with a pH ranging between 2.6-3.2 (Kolfschoten & Yarrow, 1970). However, it appears to constitute a well defined taxon that has been recovered in Belgium, Denmark, France, Norway, the Netherlands and the United States (Kolfschoten & Yarrow, 1970) and that has a coenzyme Q-9 system (Yamada et al., 1980) and 42.2-43.4 mol % of G + C nuclear DNA (Barnett et al., 1983).

Acknowledgments

We acknowledge with appreciation the critical review of the manuscript by Mary Jane Gantt. The work was supported in part by the National Science Foundation Grants DEB 7921031 and BSR 8413523 and by the National Institutes of Health Contract N01-RR-2-2139.

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MYCOTAXON

Vol. XXV, No. 1, pp. 153-158 January-March 1986

TOLYPOCLADIUM, A SYNOMYM OF BEAUVERIA

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A comparision of their type specimes shows that Tolypocladium W. Gams cannot be satisfactorily separated from Beauveria Vuill. They have similar conidiogenous structures and similar, white, lanose or slightly fasciculate colonies. Fig. 1a shows camera lucida drawings of Beauveria bassiana (Bals.) Vuill., and Fig. 1b of Tolypocladium niveum (Rostr.) Bisset = T. inflatum W. Gams. Both fungi form botryose, swollen conidiogenous cells on short conidiophores, composed of a single swollen cell or a short row of swollen cells. Each conidiogenous cell forms a peg-like, often curved conidiogenous rhachis, which elongates sympodially or percurrently. The conidia are small (2-4 µm), obovate or spherical, aseptate, hyaline, with a minute basal scar. Supplementary ampulliform phialide-like cells are present in both species. The conidia develop in basipetal sequence and are similar to the conidia formed on scars of the elongating conidiogenous rhachis.

In B. bassiana the conidiogenous rhachis often becomes zig-zag and the scars are distinctly protuberant. In B. brongniartii (Sacc.) Petch, however, the conidiogenous rhachis is shorter, not zig-zag, and the scars of the conidia are sessile or only slightly protuberant as they are in T. niveum.

The fungus known as Acremonium arenarium Petch or Aphanocladium arenarium (Petch) W. Gams is also congeneric with B. bassiana (Fig. 1c). The conidiogenous cells often form a single conidium on a peg-like stalk, but this also may elongate sympodially, occasionally with distinct, denticle-like elongations. In older cultures, conidiogenous pegs also develop from swollen cells of the aerial hyphae.

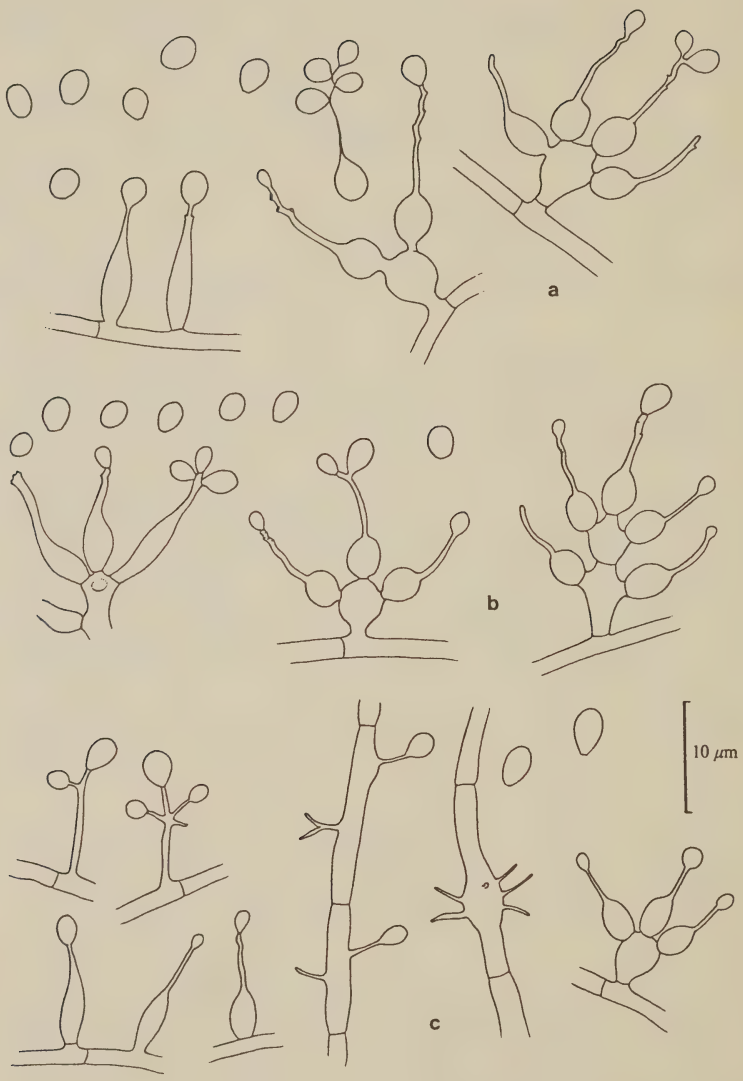

Fig. 1. a. Beauveria bassiana (fresh isolate); b. Beauveria nivea (fresh isolate); c. Beauveria arenaria (CBS 781.66).

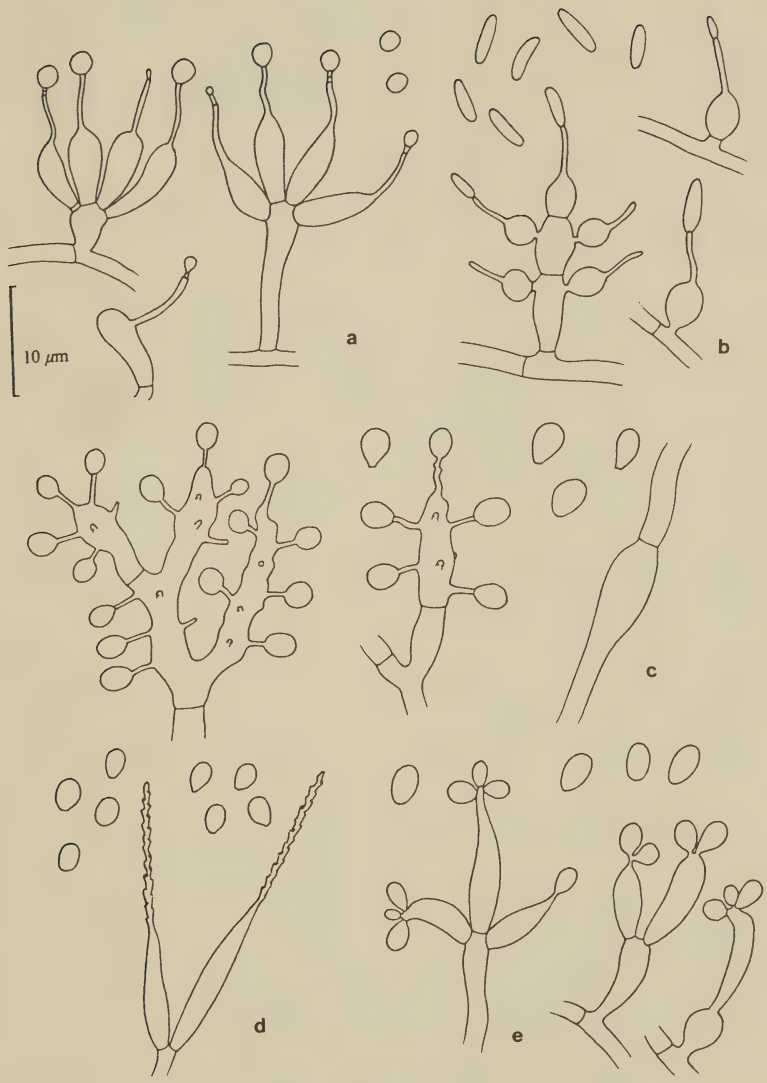

Fig. 2. a. Beauveria geodes (CBS 723.70); b. Beauveria cylindrospora (CBS 718.70); c. Myriodontium keratinophilum (CBS 974.73); d. Engyodontium album (CBS 348.55); e. Isaria felina (CBS 250.34).

Beauveria has been revised by de Hoog (1972). He accepted three species, viz. B. bassiana, B. brongniartii and B. alba (Limber) Saccas. The last mentioned species he transferred in 1978 to a new genus Engyodontium as E. album (Limber) de Hoog. This species differs from typical Beauveria species by elongate-obclavate conidiogenous cells with a long conidiogenous rhachis, covered with numerous slightly protuberant scars (Fig. 2d).

Two species recently have been added to Beauveria, viz. B. amorpha (Höhnel) Samson & Evans with allantoid or short cylindrical conidia and B. velata Samson & Evans with ovate, punctulate conidia (Samson and Evans, 1982). Carmichael et al. (1980) transferred Isaria felina Fr. to Beauveria. This synnematous species differs from typical Beauveria species by the conidiogenous cells, which are cylindrical-clavate or ampulliform and without a distinctly elongating rhachis. The conidia are formed successively in a compact apical whorl (Fig. 2e). The classification of this species in Isaria or Beauveria is debatable.

The following species are reclassified in Beauveria:

Beauveria nivea (Rostrup) comb. nov. - Fig. 1b.
Pachybasium niveum Rostrup - Dansk bot. Ark. 2, 5: 41. 1916 (basionym).
Tolypocladium niveum (Rostrup) Bisset - Canad. J. Bot. 61: 1312. 1983.
Tolypocladium inflatum W. Gams - Persoonia 6: 185. 1971.

Beauveria cylindrospora (W. Gams) comb. nov. - Fig. 2b.
Tolypocladium cylindrosporum W. Gams - Persoonia 6: 187. 1971 (basionym).

Beauveria geodes (W. Gams) comb. nov. - Fig. 2a.
Tolypocladium geodes W. Gams - Persoonia 6: 187. 1971 (basionym).

Beauveria nubicola (Bisset) comb. nov.
Tolypocladium nubicola Bisset - Can. J. Bot. 61: 1320. 1983 (basionym).

Beauveria parasitica (Barron) comb. nov.
Tolypocladium parasiticum Barron - Can. J. Bot. 58: 439. 1980 (basionym).

This species has been isolated from soil-inhabiting rotifers. Its colonies grow very slowly and the conidiogenous rhachis elongates percurrently, with rather distinct annellations in age.

Beauveria tundrense (Bisset) comb. nov.
Tolypocladium tundrense Bisset - Can. J. Bot. 61: 1322. 1983 (basionym).

Beauveria arenaria (Petch) comb. nov. - Fig. 1c.
Acremonium arenarium Petch - Trans. Br. mycol. Soc. 16: 242. 1932 (basionym).
Aphanocladium arenarium (Petch) W. Gams - Cephalosporium-artige Schimmelpilze p. 198. 1971.

Fig. 1c was prepared in 1966 from a fresh isolate received from Dr. M. C. Papendorf (Potchefstroom, South Africa). This strain was isolated from litter. Other strains of B. arenaria have been isolated from spiders and have been collected mainly in tropical areas.

The genus Aphanocladium W. Gams is based on Acremonium album Preuss, a mycoparasitic fungus, first observed on Cribraria vulgaris (Myxomycota). The type species was not examined. Several strains were studied isolated from Agaricus bisporus and other fungi and identified by Dr. W. Gams (e. g. CBS 411.34 and 798.84). On cornmeal agar all produce white colonies with abundant aerial mycelium of narrow hyphae and a red exudate. Obclavate or lanceolate conidiogenous cells develop laterally on unthickened aerial hyphae. The solitary conidia are ovate or broadly clavate, aseptate, hyaline, have an often slightly truncate base and measure 4-7 x 2.5-4 µm (Fig. 3). No conidia aggregated in droplets or chains were observed. The genus Aphanocladium should be restricted to this peculiar species of uncertain affinity. It also occurs on rust fungi and induces the formation of telia (Biali et al., 1972).

Bisset (1983) classified several more species in Tolypocladium, which, however, do not form swollen conidiogenous cells with a narrow and elongating conidiogenous rhachis and which will have to be transferred to other genera. Such a species is Gliocladium microsporum (Jaap) comb. nov. with the basionym Verticillium microsporum Jaap (Verh. bot. Ver. Prov. Brandenb. 58: 38. 1916).

Also compared with Beauveria was Myriodontium keratinophilum Samson & Polonelli, which forms white colonies and small, aseptate, hyaline conidia on distinct stalks (Fig. 2c). The conidiophores are often aggregated in sporodochial tufts and the usually integrated, often intercalary conidiogenous cells are relatively broad and elongate sympodially. Other genera related to Beauveria are Phialocladus Kreisel with a single species growing in association with termites, Pleurodesmospora Samson et al. with a fungicolous species forming catenate conidia in basipetal sequence, Culicinomyces Couch et al. with a single species parasitic on mosquito larvae, also with apparently basipetal conidia, and Beauveriophora Matsushima.

Fig. 3. Aphanocladium album (CBS 794.84).

Teleomorphs are unknown in Beauveria, but apparently would belong to the Clavicipitaceae (Cordyceps, Torrubiella and related genera). The entomogenous genus Hirsutella Pat. differs from Beauveria by larger , often sheated conidia and lanceolate, only slightly swollen conidiogenous cells (Minter and Brady, 1980).

Acknowledgements

The author thanks Prof. E. Müller, Dr. G. S. de Hoog and Dr. K. A. Seifert for useful suggestions and comments, and for reading the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 159-160 January-March 1986

MODIFICATION OF NOBLES' SPECIES CODE FOR IDENTIFICATION OF BASIDIOMYCETE CULTURES

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The numerical species code developed by Nobles (1965) for identification of basidiomycete cultures has been modified and supplemented by a number of workers. These include Boidin (1966), Nobles (1967), Burdsall *et al.* (1978), Burdsall & Nakasone (1981), and Boidin & Lanquetin (1983). Two additional modifications are proposed in this paper.

1. Regarding Character No. 28

Boidin & Lanquetin (1983) used character no. 28 for "dextrinoid asterohyphidia." That number, however, was already occupied. Burdsall & Nakasone (1981) had assigned no. 28 to "capitulate spines on vegetative hyphae." I propose that the dextrinoid asterohyphidia be assigned to character no. 29.

2. Regarding Stephanocysts

Structures first called "caliciform structures" by Litschauer (1928) were later called *stephanocysts* by Boidin (1950). These are characteristic of several species of *Hyphoderma* Wallr. (Corticiaceae). Burdsall (1969) gives a detailed account of these curious hyphal modifications. Stephanocysts may be one- or two-celled and usually possess a ring of spine-like projections at the midline between the two cells (FIG. 1) or at the base of the sessile type (FIG. 2). The function of stephanocysts is unknown, but they may serve as propagules. I propose that stephanocysts be assigned to character no. 30 in Nobles' system.

<u>The following characters are assigned</u>:

28. Capitulate spines on vegetative hyphae
29. Dextrinoid asterohyphidia
30. Stephanocysts

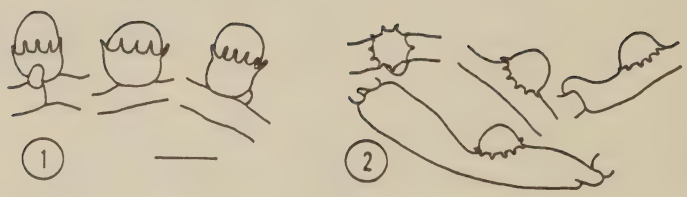

FIG. 1. Stephanocysts from culture of *Hyphoderma praetermissum* (Karst.) J. Erikss. & Strid in Erikss. & Ryv., RLG-11467-Sp. FIG. 2. Stephanocysts from culture of *H. puberum* (Fr.:Fr.) Wallr., RLG-9652-Sp. Scale bar = 10 µm. Both cultures ex USDA Forest Products Lab., Madison, Wisc.

ACKNOWLEDGMENT

Thanks to Mrs. F.F. Lombard for her comments on the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 161-164 January-March 1986

DERMATISCUM FALLAX (PHYSCIACEAE), A NEW LICHEN FROM SOUTHERN AFRICA

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ABSTRACT

A new lichen, *Dermatiscum fallax* (Physciaceae), is described from southern Africa. Its relationship to *Dermatiscum thunbergii* is discussed, as is its distribution and chemistry.

DERMATISCUM FALLAX Brusse, *sp. nov.*

Thallus ut in *Dermatiscum thunbergii* (Ach.) Nyl., sed cortice superiore tenuiore et acido rhizocarpico deficienti.

Thallus cinereus, peltatus, saxicola, usque ad 3 cm diametro, 400 - 800 µm crassus. *Cortex superior* 10 - 15 µm crassus, anticlinate prosoplectenchymatus. *Stratum gonidiale* 25 - 80 µm crassum, algis *Trebouxiis*, 6 - 16 µm diametris. *Medulla* alba, 280 - 650 µm crassa. *Cortex inferior* 30 - 80 µm crassus, anticlinate prosoplectenchymatus, hyphis conglutinatis, hyalinus, sed zonis exteriore atrobadius. *Stratum epinecrale* atrobadium, irregulare. *Apothecia* lecanorina, usque ad 1 mm diametris, primum immersa deinde sessilia, leviter convexa, fuliginea. *Thecium* pallide stramineum vel hyalinum, 120 - 200 µm crassum. *Excipulum* reductum (ut in *Dermatiscum thunbergii*). *Hypothecium* pallide stramineum vel hyalinum, 70 - 120 µm crassum, J+ leviter caeruleum, paraplectenchymatum, cellulis 4 - 7 µm diametris. *Hymenium* pallide stramineum vel hyalinum, 50 - 80 µm altum, J+ caeruleum. *Epihymenium* fuscum cum hydroxido kalii non reagens, et in acidum nitricum ad rosescens mutans. *Paraphyses* capitatae, fere simplices, septatae, circa 1.5 µm crassae, capitibus 3 - 5 µm crassis,

0 - 1 septatis, cum teguminibus gelatinarum fuscus. *Gelatina* J+ caerulea. *Asci* clavati, cum tholis J+ caeruleis, ut in *Physciis*. *Ascosporae* octonae, badiae, uniseptatae, ellipsoideae, cum toris et parietibus aequis, ut in *Dimelaenis*, 8.5 - 13 x 5.5 - 7.5 µm. *Pycnidia* globosa, hyalina, immersa, 100 - 120 x 70 - 100 µm. *Pycnidiosporae* hyalinae, bacillares, rectae, 5 - 8 x 0.8 µm. *Thallus* acidum squamaticum continens.

TYPUS: South Africa, Cape Province, Pakhuis Pass near Clanwilliam, on Table Mountain sandstone boulder, *F. Brusse 1102*, 8. ii .1977 (PRE, holo- ; BM, iso-), fig. 1.

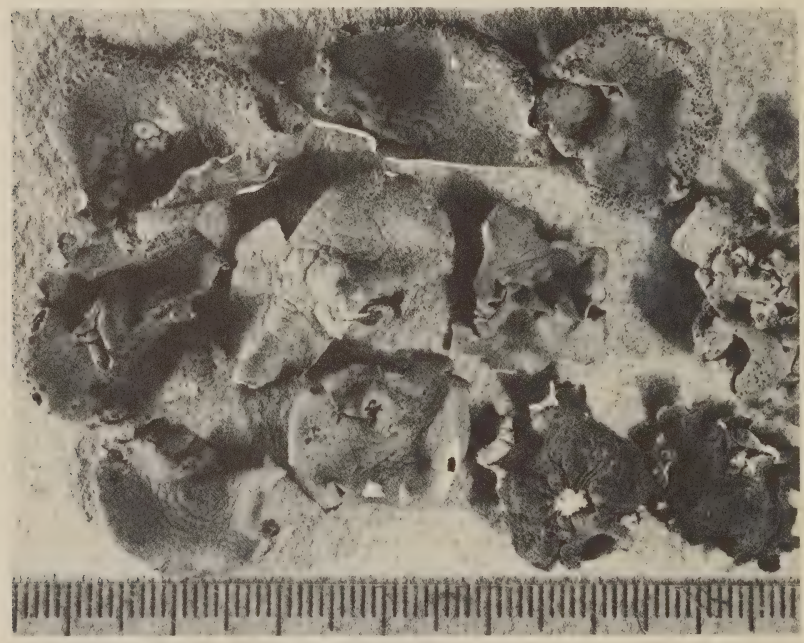

Fig. 1. *Dermatiscum fallax*, habit. F. Brusse 1102, holotype. Scale in mm.

Thallus as in *Dermatiscum thunbergii* (Ach.) Nyl., but upper cortex thinner and lacking rhizocarpic acid.

Thallus saxicolous, grey, peltate, to 3 cm diam., 400 - 800 µm thick. *Upper cortex* 10 - 15 µm thick, anticlinal prosoplectenchyma. *Algal layer* 25 - 80 µm thick. Algae *Trebouxia*, 6 - 16 µm diam. *Medulla* white, 280 - 650 µm

thick. *Lower cortex* 30 - 80 µm, anticlinal prosoplectenchyma with conglutinate hyphae, hyaline but dark brown below. *Epinecral zone* irregular, dark brown. *Apothecia* lecanorine, to 1 mm diam., immersed at first then sessile, convex, sooty coloured. *Thecium* pale straw coloured or hyaline, 120 - 200 µm thick. *Exciple* reduced or absent (as in *Dermatiscum thunbergii*). *Hypothecium* pale straw or hyaline, 70 - 120 µm thick, I+ pale blue, paraplectenchymatous, cells 4 - 7 µm diam. *Hymenium* pale straw to hyaline, 50 - 80 µm high, I+ blue. *Epihymenium* brownish, not changing in potassium hydroxide, becoming pinkish in nitric acid. *Paraphyses* capitate, simple, septate, *c.* 1.5 µm thick, apices 3 - 5 µm thick, 0 - 1 septate, with brown gelatinous caps. *Gel* I+ blue. *Asci* clavate, 8 - spored, tholi I+ blue, as in *Physcia*. *Ascospores* brown, uniseptate, ellipsoid, torus and even walls as in *Dimelaena*, 8.5 - 13 x 5.5 - 7.5 µm. *Pycnidia* globose, hyaline, immersed, 100 - 120 x 70 - 100 µm. *Pycnidiospores* hyaline, straight rods, 5 - 8 x 0.8 µm. *Chemistry:* squamatic acid and an unidentified terpene present.

Dermatiscum fallax is closely related to the strikingly yellow-coloured *Dermatiscum thunbergii*, but differs in the thinner upper cortex which also lacks the yellow pigment rhizocarpic acid of that species; the upper cortex of *D. fallax* is 10 - 15 µm thick, whereas that of the latter species is 30 - 40 µm thick. The two species are otherwise very similar and must be closely related. The relationships of the genus *Dermatiscum* to other members of the Physciaceae are discussed by Hafellner, Mayrhofer & Poelt (1979). However, the family is heterogeneous as discussed by them, including as it does genera with various ascus types.

The medullary chemistry of the two species show different trends as well. All (8) the samples of *D. thunbergii* that I have examined (South Africa only), contain gyrophoric acid. *D. fallax* may also contain gyrophoric acid, but it often contains thamnolic acid as well. Squamatic acid is also known (type). Harper & Letcher (1966) found squamatic acid in *D. thunbergii* from Zimbabwe, and it seems certain that these are only chemical strains, which cannot be correlated to any morphological trend.

An interesting ecological separation of chemical strains of this species was observed at Tradouw Pass near Barrydale, where many thalli (small at this locality) were collected from two different aspects of a large Table Mountain sandstone outcrop. The thalli from the steeper north

face all contained gyrophoric acid only, whereas all the thalli from the gentler south face contained both gyrophoric and thamnolic acids, the latter easily visualized by its K+ rich yellow reaction. However thalli containing gyrophoric acid only,have been collected on south faces at other localities.

This second species of *Dermatiscum* from southern Africa, occurs only in the Cape floral area, where it is common.

SPECIMENS EXAMINED: SOUTH AFRICA, Cape Province - 3218 (Clanwilliam): Pakhuis Pass near Clanwilliam (-BB), *F. Brusse 1102*, 8.ii.1977, 610 - 670 m (type; squamatic acid; BM, PRE). 3320 (Montagu): 4 km SW of Montagu, Kogmans Kloof near the old British fort of 1899, on top of an E - W ridge, on S sides of TMS outcrops (-CC), *F. Brusse 3741*, 12.v.1981, 200 - 250 m (gyrophoric acid only; PRE); 7 km S of winery at Barrydale, Tradouw Pass, Langeberg, on TMS on S slope (-DC), *F. Brusse 3673*, 11.v.1981, 300 - 350 m (gyrophoric and thamnolic acids; BM, PRE); 7 km S of winery at Barrydale, Tradouw Pass, Langeberg, on N side of TMS outcrop, on a general SW slope (-DC), *F. Brusse 3674*, 11.v.1981, 300 - 350 m (gyrophoric acid only; BM, PRE). 3321 (Ladismith): Seven Weeks Poort, about 16½ km from the main Calitzdorp - Ladismith road, on large TMS boulder in the cove of a high water trickle (waterfall), (-AD), *F. Brusse 3552*, 9.v.1981, 850 - 950 m (gyrophoric and thamnolic acids; PRE).

ACKNOWLEDGEMENTS

The author would like to thank the South African Department of Agriculture and Water Supply for financial support of this study. Thanks are also due to Mrs A. J. Romanowski for the photography and to Mrs S.M. Thiart for the typing. The author is grateful to Mr. P. W. James for reviewing the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 165-174 January-March 1986

ON THE ANAMORPH OF PHILLIPSIA CRISPATA

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SUMMARY

The genus Molliardiomyces is emended to include species with both sympodial and percurrent proliferation of conidiogenous cells. The new species M. crispatus, the anamorph of Phillipsia crispata is described. In M. crispatus, proliferation of conidiogenous cells is usually percurrent, sometimes sympodial. In all other known species of Molliardiomyces proliferation is sympodial. This is the first reported instance of percurrent proliferation in an anamorph of a species of the Pezizales.

Phillipsia crispata (Berk. & Curt. in Berk.) Le Gal is a species of the Sarcoscyphaceae (Pezizales, Sarcoscyphineae) that is widely distributed in the neotropics (Denison, 1969). Cultures obtained from a strain of P. crispata collected in Costa Rica have produced an anamorph in which proliferation of conidiogenous cells is most commonly percurrent (annellidic), but is sometimes sympodial. The conidia are produced holoblastically and accumulate in small, mucoid masses. Were it not for the percurrent mode of proliferation, the P. crispata anamorph could readily be accomodated in Molliardiomyces Paden, a genus recently described for the anamorphs of species of several genera of the Sarcoscyphaceae, including Phillipsia spp. (Paden, 1984). Proliferation in Molliardiomyces, as presently

circumscribed, is sympodial. If the P. crispata anamorph is to be treated as a species of Molliardiomyces, then that genus should be amended to include percurrent proliferation of conidiogenous cells. This problem has been discussed in Sporidesmiella Kirk by Zhang et al (1983). In S. hyalosperma (Corda) Kirk var. hyalosperma proliferation is percurrent; in var. novaezelandiae Hughes proliferation is sympodial. In S. brachysporioides Zhang & Kendrick proliferation is sympodial; however broken-off conidiophores will occasionally resume vegetative growth by percurrent proliferation. In the Diatrypaceae Glawe (1983a, b; 1984), and Glawe and Rogers (1982a, b) have shown both sympodial and percurrent proliferation in Cryptosphaeria pullmanensis, Eutypella parasitica, and species of Diatrype, Diatrypella, Eutypa, and Eutypella.

Because of the close similarity of the P. crispata anamorph to species already described in Molliardiomyces, and taking into account the reports of Zhang et al., Glawe, and Glawe and Rogers previously cited, Molliardiomyces is emended to include species showing both sympodial and percurrent proliferation.

MATERIALS AND METHODS

Cultures were obtained from germinated ascospores from apothecia collected at the Centro Agronomico Tropical de Investigación y Enseñanza (C.A.T.I.E.), Turrialba, Costa Rica. Pieces of apothecia were suspended over plates of 2% Difco agar containing aureomycin + streptomycin (2.5/250 ppm). Germinated ascospores were cut out after 24 hr and transferred to potato-carrot agar (PCA) plates (Dade, 1960). Cultures have been maintained on PCA. For observation of cultural characters and the anamorph, cultures were incubated at 23-24 C in 9 cm plastic Petri dishes exposed to diurnal illumination from a cool-white fluorescent tube.

Molliardiomyces Paden, Can. J. Bot. 62: 211. 1984, emend.

Ad instar generis, sed conidiophoris sympodice et percurrenter proliferantibus.

Phillipsia crispata (Berk. & Curt. in Berk.) Le Gal, Discom. de Madagascar 262. 1953.

Stat. anam. Molliardiomyces crispatus Paden, sp. nov.

Conidiophora repentia, ramosa vel simplicia, hyalina, laevia, typice curvata, percurrenter vel sympodice proliferantia, 8-45 X 1.6-5.6 µm; conidis holoblasticis, inseptatis, hyalinis, laevibus, ovatis, obovatis, ellipsoideis vel oblongatis-ellipsoideis, frequenter inaequilateris, 9.6-19.3 X 5.8-8.8 µm, ad basim truncatis vel cum appendice, singulatim vel brevibus catenis productis, in mucilaginosis massulis accumulantibus.

Cultura exsiccata in agaro JWP 1103, Holotypus.

Colonies on PCA up to 70 mm in diam in 14 da at 23-24 C, colorless and mostly submerged except for some white, floccose aerial mycelium in the central part of the colony; margin irregular; reverse colorless. Conidiophores and conidia produced after about 1 month. Conidiophores 8-45 X 1.6-5.6 µm, smooth, colorless, usually curved, unbranched or branched, usually but not always tapered toward the apex, proliferation of conidiogenous cells usually percurrent, sometimes sympodial, producing conidia holoblastically. Conidia smooth, hyaline, 1-celled, broadly ovate, obovate, ellipsoid, or oblong-ellipsoid, frequently unequal-sided or with the base eccentrically positioned, 9.6-19.3 x 5.8-8.8 µm, with a distinctly truncate base and often a basal frill or appendage, borne singly or in short chains of 2 or 3, accumulating in small mucilaginous masses. Germination has not been observed.

Colonies on Czapek's agar (Raper and Thom, 1949) restricted, 32-37 mm in diam in 30 da at 23-24 C, colorless, appressed, sterile; margin irregular; reverse colorless.

Description based on a culture from JWP 1103, Centro Agronomico Tropical de Investigación y Enseñanza (C.A.T.I.E.), Turrialba, Costa Rica, Nov. 5, 1975 (UVIC).

Type: a dried culture deposited at UVIC.

DISCUSSION

In the P. crispata anamorph described herein, proliferation of conidiogenous cells is usually percurrent (annellidic), but is sometimes sympodial. This is the first report of percurrent proliferation in an anamorph of a species of the Pezizales. It is described as a species of Molliardiomyces, as emended. This concept of Molliardiomyces is in accord with the inclusion in Sporidesmiella of species with both sympodial and percurrent proliferation by Zhang, et al (1983), and the reports of Glawe (1983a, b; 1984), and Glawe and Rogers (1982a, b) of both types of proliferation in species of the Diatrypaceae. Glawe and Rogers (1982b) have noted that the finding of both types of proliferation in several species of the Diatrypaceae indicates that they are not very distinct or invariable in those fungi. For additional discussion see Zhang, et al (1983). With the exception of the percurrent proliferation of most conidiogenous cells, the P. crispata anamorph closely resembles species of Molliardiomyces previously described (Paden, 1984).

Considerable variation was noted with regard to the presence or absence of an appendage on the conidia. Some conidia simply had truncate bases. In other cases the end of a conidiophore became slightly enlarged and adhered to the conidium as an appendage (Figs. 9, 14), or remained attached to the conidiophore (Fig. 8). Conidia were sometimes borne in short chains (Figs. 3, 5, 12). It is possible that the appendages represent aborted or partially developed conidia. The conidia are multinucleate (Fig. 13), as are conidia of other Phillipsia spp. (Paden, unpublished).

Paden (1975) described ascospore germination and the formation of arthroconidial (thallic) anamorphs in Cookeina sulcipes (Berk.) O. Kuntze and P. crispata. This report now appears to be in error, at least with regard to the P. crispata anamorph, and probably also for C. sulcipes. The culture on which the present study is based (JWP 1103) is different from that of the 1975 report (JWP 1104). The latter is most likely a contaminant. The ascospore germination data (Paden, 1975) are still valid. Hopefully, new cultures of C. sulcipes can be obtained in the future.

ACKNOWLEDGEMENTS

This research was supported by grants from the Natural Sciences and Engineering Research Council of Canada (grant No. A-4437) and the University of Victoria. I thank Dr. Peter L. Smith for correcting the Latin diagnoses and Dr. Jack D. Rogers for reviewing the manscript.

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PLATES

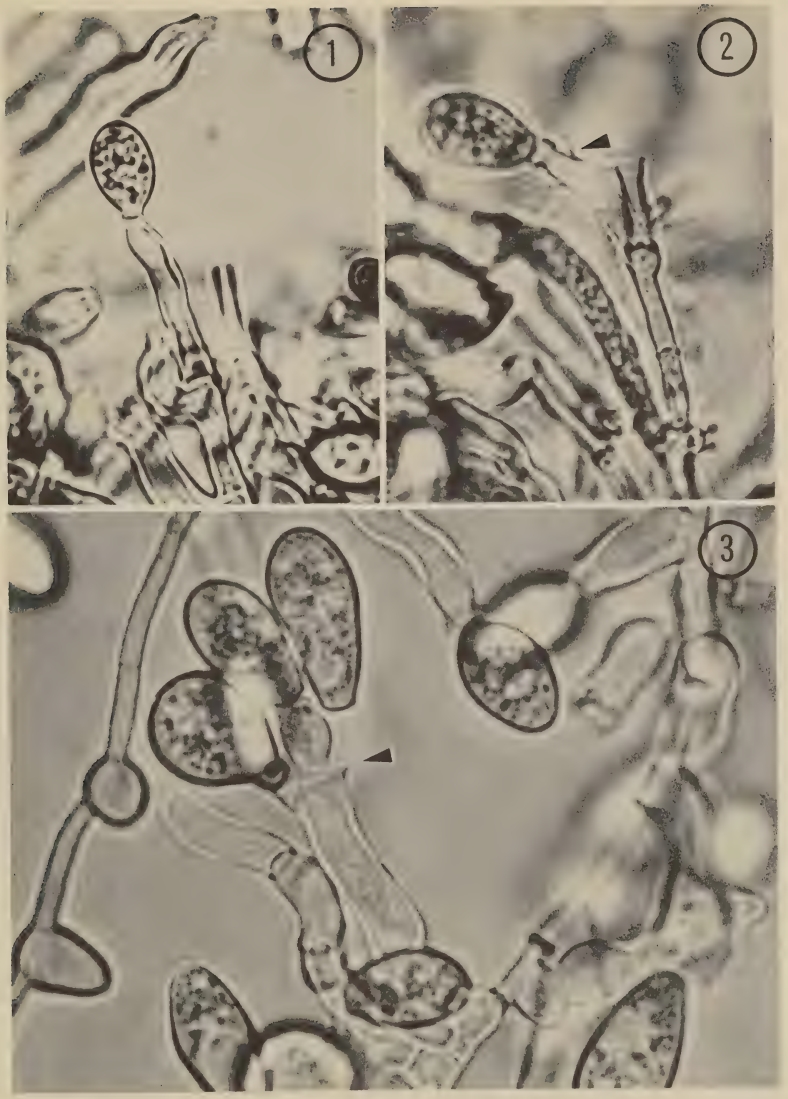
(on pages that follow)

FIGS. 1-3: Phillipsia crispata. 1. Conidiophore producing first conidium. No annellation evident. X 1230. 2. Conidiophore producing second conidium. One annellation evident (arrow). The conidium on the left appears to have been produced sympodially. The large cell below the center conidium may be developing into a second conidium in a short chain. X. 1530.

FIGS. 4-7: Phillipsia crispata. 4. Two conidia appearing to be produced sympodially. X 1270. 5. Two conidia borne in a short chain. No annellations evident. X 1550. 6. Conidia borne in short chains with annellations evident (arrows). X 1550. 7. Conidium produced percurrently with the upper part of the conidiophore somewhat swollen, but not deliminated by a septum. X 1430.

FIGS. 8-10: Phillipsia crispata. 8. Conidia produced percurrently. The slightly swollen upper portion of the conidiophore on the left has not become attached to the conidium. X 1300. 9. Conidium produced percurrently. The upper part of the conidiophore is attached to the conidium as an appendage. X 1430. 10. Conidia produced sympodially, except at the lower left where an annellation is evident (arrow). X 1730.

FIGS. 11-14: Phillipsia crispata. 11. Conidia produced percurrently. Two annellations are evident on the lower conidiophore (arrows). X 1430. 12. Conidia in a short chain, produced percurrently. Annellation at arrow. X 1470. 13. Multinucleate conidia, Giemsa-stained. X 1400. 14. Conidium with basal appendage (arrow). X 1370.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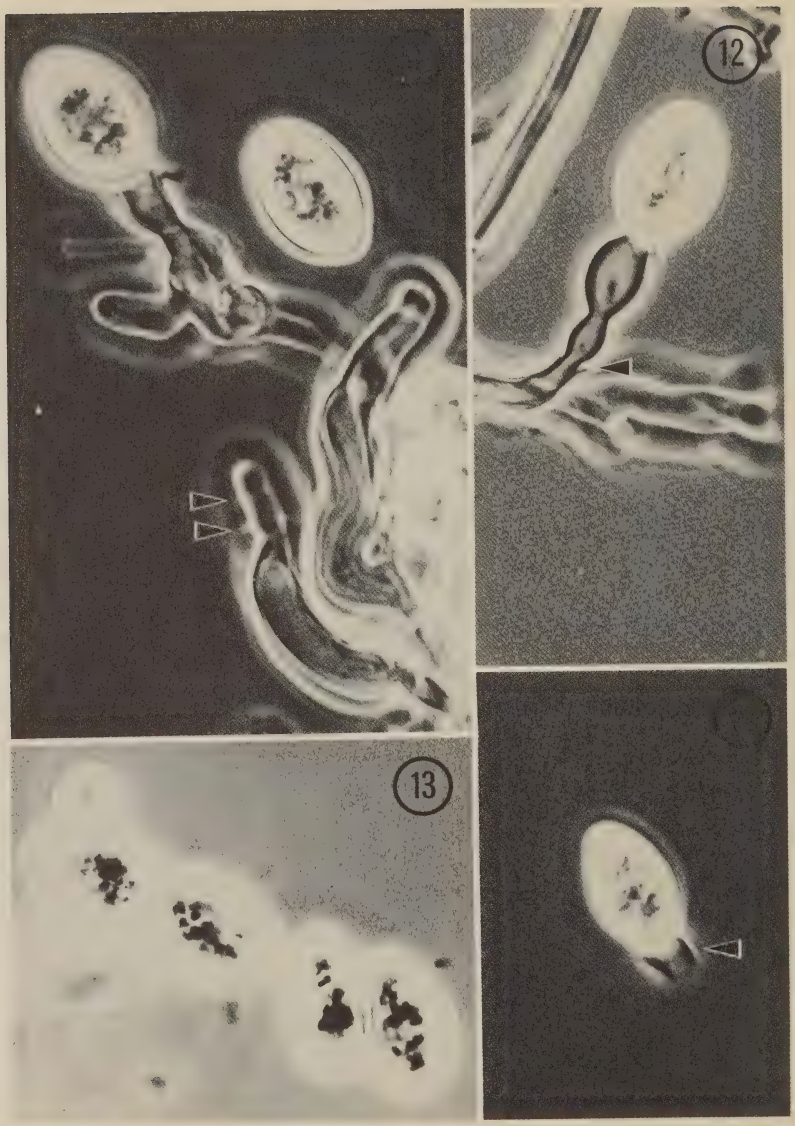
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MYCOTAXON

Vol. XXV, No. 1, pp. 175-182 January-March 1986

EXPERIENCES IN COMPUTERIZING THE NATIONAL FUNGUS COLLECTIONS' SPECIMEN LABEL DATA

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The National Fungus Collections (NFC) is associated with the Mycology Laboratory, Agriculture Research Service, U.S. Dept. of Agriculture. The collections contain about 875,000 dried fungus specimens with about 10,000 specimens added each year. The specimens are arranged in a 'phylogenetic' sequence based on Saccardo. Additional information on the collections and their history can be found in Lentz (1968).

Space charges and personnel costs associated with the maintenance of the collections are substantial. This cost demands a fuller utilization of the herbarium resources. For example, we should be able to retrieve information about individual specimens. After all, how many institutions would support the storage of books if there was no card catalog? Computers are very useful for storage, manipulation, and retrieval of specimen data, and with decreasing prices and increasing capabilities of computers their use in managing herbarium data becomes more attractive. Recognizing that label data is the key to an herbarium's holdings, the Mycology Laboratory initiated a project in 1978 to computerize the label data associated with the herbarium specimens.

This paper presents a review of the procedures developed for the project so that future efforts by other groups can benefit from our experiences. The discussion will deal with general procedures rather than details of specific hardware or software and is intended for scientists who are considering initiating a similar project. The discussion is divided into three sections: 1. History of project 2. Current procedures 3. Additional important concepts.

HISTORY OF THE PROJECT

The project has evolved through several phases, which I have listed below. Two of them (optical character recognition and use of outside contractors) are discussed in some depth as they may be of general interest.

A. Exploratory -- involving discussions with various individuals and organizations.

B. Initial data entry -- procedures developed for data entry and for handling the specimens.

C. Optical character recognition data entry -- the data stored on magnetic tape and manipulated using a remote mainframe computer.

D. Contracted data entry -- utilizing outside contractors to enter data.

E. In-house data entry -- hiring permanent personnel for data entry.

F. Complete in-house system -- purchase of hardware and software.

In the first years of the project optical scanners were used for data entry. An optical scanner is a device that is capable of scanning a page of typewritten information and transferring that information to the computer file. The information was typed on specially formatted sheets using any typewriter that can reproduce the type style required by the optical scanner. Over half the records in the current data base were entered in this manner. The mechanical nature of the process was its major disadvantage. Accurate data input from a scanner requires that the text begin at a precise location on each page, that the paper is aligned correctly in the typewriter, and that corrections are clearly typed and properly spaced. It was frequently faster to retype a sheet than it was to make a successful correction (assuming no new errors were made). Simply inserting the paper into the typewriter is time consuming.

The advantages of using the scanner for data input were:

1) It was not necessary to purchase any special computer equipment, and 2) expertise in using a computer was not required. We were able to enter a significant number of records into the computer file and then evaluate the viability of the project without committing significant financial and personnel resources except for inputting the data. The use of an optical scanner still represents a possible approach for small data bases or feasibility studies where direct (on line) access to a computer is limited.

For two years work was contracted out to an organization located outside Washington D.C. area. Photocopies of the specimen labels were sent to the contractor and completed OCR sheets returned. This procedure was discontinued for the following reasons.

1. Inability to find a qualified contractor. Contractors were not knowledgeable in herbarium practices or mycology. Training them was complicated by the physical separation.

2. Use of copied labels by contractor. Contractors were unable to check labels that did not copy well.

3. Need to critically review contractor's product. Close scrutiny of the returned data was critical to monitoring the accuracy of the contractor's work. We had to develop personnel with the necessary skills and knowledge and thus we were paying both the contractor and in house personnel to do the same job.

4. Lack of resources, especially literature. This hampered the contractor's ability to deal with questions such as spelling of scientific names. Again we found ourselves doing work that we hoped would be done by the contractor.

CURRENT PROCEDURES

The way an institution handles a project such as this depends upon the available human, computer, and financial resources. There are some factors which have general application and merit consideration when planning such a project. These factors will be discussed in the explanation of our present procedures.

A minicomputer with 300 megabytes of disc storage is currently used for the project. The typists and the computer are located in a room adjacent to the herbarium. Three typists each working 32 hours a week enter the data. One full time employee edits foreign and illegible labels. The supervision of the data entry, editing of domestic labels and preparation of the herbarium is carried out by a fifth employee who spends about 80% of his time on these activities. Temporary help (25% of a full time position) is used to assist in the numbering and copying of labels.

Because groups of related fungi are closely located in the herbarium, we have proceeded to computerize the herbarium by major fungal groups. At this time we have completed the rusts, smuts and many of the polypores making a total of 260,000 computerized specimens. With the personnel listed above, we are proceeding at the rate of 45,000 specimens per year.

Below is a list of our current procedures followed by a detailed discussion of each activity:

1. Prepare herbarium.
2. Number specimens.
3. Copy labels.
4. Segregate labels as needed for editing.
5. Edit labels.
6. Input data.
7. Proofread output against copies.
8. Make additional corrections using specialized editing printouts.

1. Prepare herbarium.

Our first activity is to make a general inspection of the portion of the herbarium to be computerized. This includes checking that the specimens are in proper order, making new folders as needed and any other changes that might be required to improve the efficiency of the computerization. By affixing the same color of tape to both the herbarium case and the genus folders and then sequentially numbering the folders contained in each case we are able to quickly and accurately replace folders removed from the cases.

2. Number specimens.

The specimens are numbered sequentially using small stick-on labels with printed numbers. It is essential that each label have a permanent unique number. During the editing, data entry and proofreading, an easy, unambiguous means of recognizing a label is necessary. Because the label data on herbarium specimens may not be unique, it can be time consuming or impossible to recognize labels based solely on the actual label data. A unique number on each specimen obviates the problem of identifying one particular label. In addition, most computer programs will allow rapid access to one particular record using a unique data element. Because not all of our specimens have accession numbers, we number packets sequentially providing an easy means to determine if all labels have been added to the computer file. This may not seem to be an important point, but in reality we have found that labels were indeed left out of the file unless some means is available of identifying the number of records in the file.

3. Copy labels.

The copy machine we use accepts "foolscap" which is identical in size to a herbarium sheet. Making copies of labels is advantageous for the following reasons:

a. A group of specimens can be removed from the herbarium, immediately copied and returned to the herbarium

lessening the possibility of misfiling specimens and reducing handling of the specimens.

b. Edited notations can be easily added prior to typing. A significant number of labels required some annotation before the data could be efficiently entered by the typists.

c. Labels can be segregated for specific editors.

d. Herbarium sheets are difficult to type from.

The diversity of labels in terms of color of paper and clarity of writing present a challenge to the copying process. Copy machines with user adjustable contrast are best suited for this type of copying. Even with a versatile copy machine, some copies have to be edited using the original label.

4. Segregate labels as needed for editing.

At this stage we segregate labels that have difficult handwriting or unclear locality information and give them to the knowledgeable individual who works full time on editing.

5. Edit labels.

The editors clarify information about localities, correct spellings and write out data that is difficult to read and add other notations necessary to assist the typists in inputting the data. To derive maximum value from the data base, consistency of data entry is important. To assure consistency in editing and entering data, a set of data entry standards has been formulated. These instructions cover in detail how the various elements of the label are to be entered. Included are items such as the type of information to be entered in each field, the format for entering the data, the punctuation to be used in separating the different data elements in each field and how to enter atypical data such as a date "during the summer of 1976." These instructions answer questions that might arise during the editing or inputting of the label data. These instructions have a "biblical" status and adherence to these instructions is mandatory. They are modified or added to only after consultation with the relevant higher authority.

Searching the data base for a particular type of data is greatly facilitated if you know exactly how the data has been entered in all cases. Another institution or individual can more easily incorporate your data into their system if it is known exactly how your data is organized. I transferred 190,000 records from our original software program to an entirely different software running on the laboratory's minicomputer. The success and efficiency of

this transfer were a direct result of the consistency of the data entry.

6. Input data.

At this stage the software being used and your ability to take full advantage of its capabilities can have a significant effect on the overall efficiency of the project. A high degree of control over the data entered is possible. For example we maintain a computer list of the genera in our herbarium. When generic names are entered they are automatically checked against this list and if a corresponding name is not found on the list the typist is requested to re-enter the data. Thus consistency in the data entry is assured and the time needed for proofreading is reduced.

7. Proofread output against copies.

At the end of each day a printout of the labels typed by each typist is produced. This printout is proofread against the copies of the labels by a different typist. A supervisor then reviews all the corrected printouts and records the number of errors and number of records for each typist.

8. Editing printouts

The computer is used to generate special printouts for additional editing. For example, we make an alphabetical listing of collectors to check further for misspellings and consistency of data entry. These printouts are created as we complete each herbarium case. At this time we also check that all specimens in the case have been entered.

Progress of the project is closely monitored. We can accurately assess that the data is being correctly and consistently entered and that individuals are working at a reasonable level of efficiency by daily proofreading, by a review of the data for each herbarium case, and by a tally of the number of records typed each day. Monthly totals of records typed are noted in order to monitor the rate of progress. Without this type of continuous examination we have found it very easy to fall prey to inconsistent data entry and lowered efficiency. Equally important regular monitoring allows the early detection of problems so that they can be dealt with immediately.

ADDITIONAL CONSIDERATIONS

Our experience suggests the following guidelines:

1. Do not get bogged down with extraneous data that is not critical to meeting the goals of the project. Solving all the nomenclatural or taxonomic problems before entering the data will slow progress in computerization. Such

problems can generally be handled more efficiently after the data has been entered.

2. Establish well-defined, attainable, long-term, sort-term and intermediate goals. These goals are helpful in providing a realistic picture of the rate at which the project is progressing; daily or monthly rates don't clearly indicate the overall efficiency of the project. The impact of illness, vacation time, holidays, delays due to computer malfunction, and other miscellaneous activities can only be assessed over a period of several months. A short term goal provides an opportunity to stop and evaluate procedures. Intermediate goals provide the members of the project with an indicator of the project's progress and are positive reinforcements of their contributions toward its completion.

3. Communicate. All parties must participate in developing the procedures to be followed; whenever we failed to do so, efficiency was reduced. The success of a project of this type is dependent on the efficiency of the typists and their comments and suggestions must be carefully considered. Elaborate programming by the computer people will be of no value unless the needs of the typists are taken into consideration.

4. Develop adequate computer expertise. Every location will have a different mix of computer expertise, hardware, and software and thus it is difficult to make any broad generalizations about how best to make use of these resources. I doubt that a project of this type can be carried out without a member of the staff developing some interest in and knowledge of computers. This does not have to be prior knowledge, but can be knowledge gained during the course of the project. We started the project without any computer expertise and thus were dependent on outside help. Available options and the the opinions of others should be considered in order to determine the appropriate procedures. The use of a pilot project will help to clarify the correctness of your decisions.

5. Computerize new accessions. Even if you don't anticipate doing the backlog of herbarium specimens, I strongly urge that the accession of new specimens be automated. Specimen labels can easily be generated from computer records. Replacement of damaged labels or erroneous labels or new labels with annotations are easily produced. Adding new specimens to a computer file assures that the backlog will not increase. Many of the computer data bases such as Bioabstracts which make no attempt to enter the old data have become quite valuable with the passage of time.

7. Demand accuracy in accessioning specimens. During the 100-plus-year history of the National Fungus Collections, the quality of the label preparation has varied greatly. The computerization project is considerably

more difficult because of lazy, sloppy, and inaccurate preparation of original labels. We have had to devote scarce resources to correcting problems which never would have occurred in the first place if there had been adequate quality control when the labels were prepared. Even if computerization of an herbarium is not contemplated, resources should be devoted to monitoring the current label preparation. Later users of this data will greatly appreciate the effort.

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MYCOTAXON

Vol. XXV, No. 1, pp. 183-194 January-March 1986

THE ECOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF 108 SPECIES OF MACROMYCETES FROM THE SUBTROPICAL, EVERGREEN, BROAD-LEAVED FORESTS IN CHINA

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SUMMARY

From the subtropical evergreen broad-leaved forests of China, the authors collected 108 species of macromycetes. Their distribution in the whole country may be divided into eight districts. In the warm temperate broad-leaved forest, these fungi are most frequent (56% of the species recorded), and least frequent in Qing-Zang highland (8%).

In these fungi, 17 species are distributed widely in at leasts 5 districts, and 24 species have a narrow distribution in only 1 or 2 distrcts.

This article considers the influence of climatic factors on the distribution of fungi. The types of trees also influence the distribution of fungi. Among these fungi, 21 species are ectomycorrhizal, symbiotic with trees.

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* We would like express our thanks to Professor Richard P. Korf (Cornell University U.S.A.) and Professor Zang Mu (Kunming Institute of Botany, China) for their many valuble suggestions about this article.

Comparatively speaking, in China, research on vegetation has had a long history and a firm foundation, but this research was mainly on flowering plants. The macromycetes which are very important to the whole vegetation were not emphasized. In this article, from the ecological and geographical distribution of macromycetes, we analyse 108 species of fungi collected by us from subtropical evergreen broad-leaved forests. This will provide the basic data for deeper research on the Chinese vegetation, afforestation, and utilization of macromycetes.

This district (No.4 in table) is the largest vegetational district in China, accounting for 1/4 of the area in China. The northern boundary is about 34 degrees north latitude, the southern at the Tropic of Cancer, the eastern at seashore and Taiwan island, and the western limit the slope of Tibetan plateau stretching to the west boundaries of Yunnang. In District 4, the weather is of subtropical monsoons of east Asia, the accumulated temperature $\geqslant 10°C$ of the year is 4500-7500°C and the average temperature of the coldest day is 0-15°C. The non-frost season composes 250-350 days; the precipitate of a year is larger than 1000 mm, the highest up to 3000 mm, and the drying degree is smaller than 1.00.

Owing to the climatic conditions and higher plants serving as symbiotic trees, there are many species of fungi distributed in this district. The 108 species we collected belong to 22 families, comprising mostly families of the Polyporales and Agaricales, four other families of Basidiomycetes, and three families of Ascomycetes.

GEOGRAPHICAL DISTRIBUTION OF MACROMYCETES IN CHINA

These 108 species of fungi are not only distributed in this district, but most of them are distributed widely in other districts. From 'The Vegetation of China' (1980) according to flowering plant and after analysing the fungal flora of this area, eight districts may be delimited (see table; because there is no exact data for the first district, it is neglected in this table.). From the table it is clear that these fungi are also numerous in the third district, 'warm temperate broad-leaved forest' (56%). The second area is the second district, 'warm temperate coniferous and broad leaved mixed forest' and the 6th district,' temperate meadow' (34-51%), and in other districts there are lower (8-23%).

THE WIDESPREAD SPECIES

Owing to the large scope and the complex natual conditions of the fourth district, the numerous fungi which grow there are wide-spread species in China. We considered those species which grow over five districts to be the widespread species, and these fungi include 17 species. They belong to the seven families (most are Polyporaceae, Auriculariaceae, and Pleurotaceae) of the Basidiomycetes.

Their major characteristic is that the range of temperature and humidity for forming fruiting bodies is wider, so they can be distributed extensively. Most of their fruiting bodies are woody, leathery, or gelatinous, and they are not easy to rot. However, many species can be collected in different seasons.

THE NARROWLY DISTRIBUTED SPECIES

Characteristics of the weather and vegetation make some fungi to be the narrowly distributed. Their distribution is in only one or two districts in China. These fungi include 24 species. Most of them are fleshy and some are the mycorrhizal fungi symbiotic with trees. These fungi are influenced by the climatic condition and the forest. The associations of fungi with forest trees strongly affect these distributions.

DISCUSSION

All organisms exist under definite conditions, and distribution of macromycetes is related to these conditions. Here we considered chiefly the influence of climatic factors and of the symbiotic trees on the distribution of fungi.

(1) The influence of climatic factors on the distribution of fungi Wilkins (1946) considered that precipitation and temperature are the important factors for the growth and development of fungi. C. Teng (1966), by experiments, proved when the water in the substrate of fungi, e.g. Lentinus, is 180-260%, the mycelia can grow best. For the formation of fruiting bodies, the water of 260-340% is required. She divided the temperature forming fruiting bodies into three types:

1) Lower temperature: in this type, the highest temperature adopted for fruiting body formation is below 24°C. and the optimum is near 20°C.

Table I. Distribution and ecological factors of 108 species of macromycetes

Vegetational districts and ecological factors / Names of macromycetes
Agaricus rubellus (Gill.) Sacc.
A. silvicola (Vitt.) Sacc.
Agrocybe praecox (Pers.) Fayod
Amanita farinosa Schw.
A. vaginata (Bull.) Vitt.
Amauroderma longipes (Lev.) Pat.
A. rugosum (Bl. et Nees) Bres.
Astraeus hygrometricus (Pers.) Morg.
Auricularia auricula (L.) Underw.
A. delicata (Fr.) P. Henn.
A. polytricha (Mont.) Sacc.
Bjerkandera adusta (Willd.) Karst.
Boletus edulis Bull.
B. speciosus Frost
Calvatia craniiformis (Schw.) Fr.
C. lilacina (Mont. et Berk.) Lloyd
Cantharellus cibarius Fr.
C. minor Peck
Clavulinopsis amoena (Zoll. et Mor.) Corner
Clitocybe inversa (Scop.) Quel.
C. laccata (Scop.) Quel.
C. maxima (Gartn. et Mey.) Quel.
Collybia albuminosa (Berk.) Petch

	1. cold temp. forest	2. temp. coniferous broad-leaved mixed forest	3. warm temp. deciduous broad-leaved forest	4. subtropical evergreen broad-leaved forest	5. tropical monsoon & rain forest	6. temperate meadow	7. temperate desert	8. Qing-Zang highland	9. average daily temperature at the collecting time (°C)	10. monthly precipitation at the collecting time (mm)	11. *substrate	12. wide spreading	13. narrowly distributed	14. mycorrhizal
		+		+					28	176	1			
		+	+	+			+		21	219	1			
			+	+					15-21	63-127	1			
				+					28	265	1		+	
		+	+	+	+	+	+	+	22-28	282	1	+		+
				+					18	175	1		+	
				+	+				23-29	9-371	2			
		+	+	+					8-20	31-130	1			
		+	+	+	+	+	+	+	8-28	80-100	2	+		
				+	+				22-23	105-213	2			
		+	+	+	+	+	+	+	16-23	54-127	2	+		
		+	+	+	+	+	+		1-18	51-148	3	+		
		+		+					19	140	1			+
				+					19	140	1		+	+
		+	+	+					22-24	130-282	1			
		+	+	+		+	+		19	70	1	+		
		+	+	+		+			19-28	105-140	1			+
				+					27	130	1		+	
		+	+	+					122	282	1			
		+		+					22	282	1			
		+	+	+		+		+	20	130	1	+		
		+	+	+		+			21	173	1			
				+					18	140	4		+	

no exact data

C. radicata (Relh.) Quel.
C. radicata (Relh.) Quel. var. furfuracea Peck
C. velutipes (Curt.) Quel.
Coltricia cinamomea (Jacq.) Murr.
Coprinus atramentarius (Bull.) Fr.
C. micaceus (Bull.) Fr.
Coriolus consors (Berk.) Imaz.
C. hirsutus (Wulf) Quel.
C. unicolor (Bull.) Pat.
C. versicolor (L.) Quel.
Corticium luridum Bres.
Craterellus cornucopioides (L.) Pers.
Cyathus stercoreus (Schw.) de Toni
Dictyophora indusiata (Vent.) Fischer
Exidia glandulosa (Bull.) Fr.
Ganoderma applanatum (Pers.) Pat.
G. japonicum (Fr.) Lloyd
G. lucidum (Leyss.) Karst.
Guepinia spathularia (Schw.) Fr.
Hygrophorus miniatus Fr.
Hypoxylon bovei Speg. var. microspora Mill.
Inocybe asterospora Quel.
I. radiata Peck
I. repanda (Bull.) Bres.
I. rimosa (Bull.) Quel.
Irpex cinnamomeus Fr.
I. lacteus Fr.
Lactarius deliciosus (L.) Fr.
L. fuliginosus Fr.
L. hysginus Fr.
L. piperatus (Scop.) Fr.
L. volemus Fr.
Lentinus subnudus Berk.
Lenzites betulina (L.) Fr.
Lepiota americana Peck
Linderiella columnata (Bosc) Cunn.
Lycoperdon pyriforme Schaeff.
Lysurus mokusin (L.) Fr.
Marasmius oreades (Bolt.) Fr.
Morchella esculenta (L.) Pers.
Mutinus bambusinus (Zoll.) E. Fischer

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	+		+	+	+		+	18-26	60-282	1	+		
			+					20	130	1		+	
	+	+	+					6-10	64-100	2			
		+	+					19-20	91-224	1			
	+	+	+		+			21	100	1			
	+	+	+		+			23	43-137	1			
		+	+					22	282	2			
	+	+	+	+	+	+	+	18-28	74-100	6	+		
	+	+	+		+			14-26	62-208	3			
	+	+	+	+	+	+		8-22	4-282	3	+		
			+					27	178	6		+	
			+	+				28	105	1			+
	+	+	+		+			8	89	5			
		+	+	+				25-27	105	1			
		+	+			+		14	98	6			
	+	+	+	+	+			12-25	28-282	2	+		
		+	+	+				28	105	2			
	+	+	+	+				11-28	4-127	2			
	+	+	+					22	146-175	2			
	+		+					23	133	1			
			+					23	178	3		+	
			+					21	282	1		+	+
		+	+					17	149	1			
			+					17	149	1		+	
		+	+		+			18	140	1			+
			+					20	130	3		+	
	+	+	+	+	+			25	143	2	+		
	+	+	+		+			19-20	70-148	1			+
			+					28	56	1		+	+
			+					28	176	1		+	
	+	+	+					18-28	108-140	1			+
	+		+	+	+			17	127	1			+
	+	+	+					26	45	2			
	+	+	+	+	+	+		12	28	3	+		
			+					26	184	6		+	
			+					16	127	1		+	
	+	+	+		+	+		19	148	1	+		
		+	+					24	141	1			
	+	+	+					19-27	140	1			
		+	+					16-18	74-127	1			
			+					23	208	1		+	

Naematoloma fasciculare (Huds.) Harst.
Panus rudis Fr.
Paxillus involutus (Batsch) Fr.
Peziza sepiatra Cooke
P. sylvestris (Boud.) Sacc. et Trott.
P. vesiculosa Bull.
Phallus rubicundus (Bosc.) Fr.
Phellinus pomaceus (Pers.) Quel.
Pholiota adiposa (Fr.) Quel.
Pleurotus ostreatus (Jacq.) Quel.
Podoscypha diaphana (Schw.) Ito
Psathyrella candolieana (Fr.) A. H. Smith
P. velutina (Pers.) Sing.
Pseudocoprinus crenatus (Lasch) Kuhner
Rhodophyllus sinuatus (Bull.) Pat.
Russula adusta (Pers.) Fr.
R. foetens Pers.
R. integra (L.) Fr.
R. lepida Fr.
R. nigricans (Bull.) Fr.
R. pulchella Borszcz.
R. subdepallens Peck
R. vesca Fr.
R. virescens (Schaeff.) Fr.
Schizophyllum commune Fr.
Sparassis crispa (Wulf.) Fr.
Spingipellis leoninus (Kl.) Teng
Steccherinum helvolum (Lev.) Ito
Stereum purpureum (Pers.) Fr.
S. rameale (Schw.) Burt
S. spectabile Kl.
Strobilomyces floccopus (Vahl) Karst.
Suillus flavus (With.) Sing.
S. luteus (L.) Gray
Trametes cinnabarina (Jacq.) Fr.
T. cinnabarina (Jacq.) Fr. var. sanguinea (L.) Pilat
T. corrugata (Pers.) Bres.
T. dickinsii Berk.
T. gallica Fr.
T. lactinea Berk.
Tremella fuciformis Berk.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	+	+	+	+			+	14	80	2	+		
	+	+	+	+	+			21-28	107	6	+		
		+	+		+			17	127	1			+
			+					16	127	1		+	
		+	+		+			20	130	1			
		+	+					17	127	1			
	+	+	+	+				18	61-74	1			
		+	+		+			16	127	2			
		+	+		+	+		19	175	2			
	+	+	+	+		+	+	12-14	20-150	6	+		
		+	+					22	282	1			
	+	+	+			+		12-22	6-282	1			
		+	+					17-18	63-98	1			
			+					25	455	1		+	
	+		+					21	282	1			
		+	+					28	125	1			+
	+	+	+	+				22	282	1			
	+		+		+			19	148	1			+
	+		+					28	125	1			+
	+		+		+			18	140	1			
	+		+					15-18	127-283	1			+
			+		+			21	218	1			
			+					20	130	1		+	
	+		+		+			28	125	1			+
	+		+	+	+			4-24	63-139	6			
	+		+					18	140	2			
			+	+				8	89	2			
			+					26	208	2		+	
	+	+	+		+			29	282	3			
			+		+			28	79	2			
			+					19	282	3		+	
	+		+					25-28	105-150	1			+
			+					19	148	1		+	+
		+	+					14	98	1			+
	+	+	+		+	+	+	18-19	33-34	6			
		+	+					18-19	232	2	+		
			+					23-26	30-208	2		+	
	+	+	+					25	236	2			
	+	+	+		+	+		29	53	6	+		
			+	+				12	28	6			
		+	+					25	40	2			

Tricholoma sordidum (Fr.) Quel.
Xanthochrous nilgheriensis (Mont.) Teng
Xerocomus chrysenteron (Bull.) Quel.
Total number of species of district
Percentage of total number

* substrate: 1. on ground 2. on dead wood 3. on stump 4. termitophile 5. stercoricolous 6. on stem

** All specimens are preserved in Shanghai Museum of Natural History

2) Middle temperature: the maximum, below 28°C. and the optimum 20-24°C.

3) Higher temperature: the maximum, below 30°C. and the optimum 24-30°C. For each fungal sample we checked the average daily temperature and monthly precipitation at the collecting time. From this data, it may be seen that the temperature for the fruiting body formation for most fungi is 18-28°C. the lower (below 20°C.) is 41%, the middle (20-24°C.) is 31% and the higher (over 24°C.) is 28%. The monthly precipitation is 9-283mm; the lower (below 50 mm) is 7%, the middle (50-150mm) is 70% and the higher (over 150mm) is 23%.

The range of optimum temperature and precipitation for the wide-ranging species is larger, e.g. in the case of 17 species, 9 have a wide range of optium temperature and 8 species for precipitation. The climatic conditions which narrowly distributed species demand are more severe.

From the table, we can see that the species which are distributed in the temperate coniferous and broad-leaved mixed forest are the fungi of middle temperature, or lower, rarely the higher temperature. Otherwise, the species which are distributed in the tropical rain forest are the higher temperature fungi or middle temperature fungi, rarely the lower.

(2) The influence of symbiotic trees on fungal distrbution

In these 108 species, 21 species are ectotrophic mycorrhizal fungi symbiotic with trees. Beside climatic factors, their

1	2	3	4	5	6	7	8	9	10	11	12	13	14
			+	+				20	130	1			
			+					20	91-178	2		+	
	+		+					18	140	1			+
	55	60	108	25	36	16	9				17	24	21
	51	56	100	23	34	15	8				16	22	19

distribution is related to the symbiotic trees.

From the distribution of symbiotic trees, in the subtropical, evergreen, broad-leaved forest, the conifers are mainly Pinus massoniana, P. yunnanensis, Tsuga and Abies distributed at a definite elevation. In the deciduous and evergreen, broad-leaved, mixed forest of this district, Quercus, Fagus, etc, are distributed widely. Many species are the symbiotic trees for mycorrhizal fungi and the climatic conditons are suitable, so District 4 may be the main distributional district for mycorrhizal fungi.

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MYCOTAXON

Vol. XXV, No. 1, pp. 195-202 January-March 1986

ALTERNARIA THEMES AND VARIATIONS (14-16)

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PROLOGUS

Being a continuation of a series of papers primarily on *Alternaria* (Simmons 1981, 1982), in this instance a few species known on *Euphorbia*: *A. euphorbiae* (Bartholomew) E. Simmons & S. M. Francis, comb. nov. (= *Macrosporium euphorbiae* Bartholomew, 1908), *A. euphorbiicola Simmons & Engelhard, nom. nov. (= Macrosporium euphorbiae* Reichert, 1921), and *A. angustiovoidea* Simmons, sp. nov.

VI. SOME SPECIES OF ALTERNARIA ON EUPHORBIA

Some excellent cultures of an *Alternaria* species isolated from lesions on poinsettia plants (*Euphorbia pulcherrima* Willd.) became available after the 1984-85 winter commercial growing season in Florida. The isolates represent one of at least three distinct species known to me from members of this genus. Two of these species are represented by published homonyms, which need to be sorted out to prevent confusion; I believe that a third species has not been described previously in publication. Problematic material of perhaps additional distinct species will be discussed in later papers.

14. **Alternaria euphorbiae** (Bartholomew) Simmons & S. M. Francis, comb. nov. Basionym: *Macrosporium euphorbiae* Bartholomew (1908), in E. Bartholomew, Fungi Columbiani no. 2633 [description published on exsiccata label]. Fig. 27.

Lectotype [NY]: "*On living and languishing leaves of Euphorbia marginata. Stockton, Kans., July 20, 1908. E. B.*"; (EGS 03-047). Representatives of this exsiccata number also are held by several other herbaria.

We do not know of a living isolate of this species. Conidia of this fungus frequently reach a maximum body size of 90-100 x 28µm and have an apical appendage "flexuous, curved, as long or longer than the conidia" (Bartholomew, l. c.); these long filamentous beaks become about 120 x 2µm in size and, in material observed, do not become converted terminally into chain-producing conidiophores. Bartholomew gave spore-body dimensions as 40-75 x 12-20µm, which is the size range of many conidia but which does not cover the maximum sizes observed in re-examination of the type.

Conidium-body shape is ellipsoid to ovoid, becoming 8-9 transversely septate and with 1-3 longitudinal septa in some of the broadest central transverse compartments. The beak appendage is initiated at a very early stage of conidium development; a juvenile conidium about 30µm long and with only three poorly defined septa may already have a beak cell about 20µm long. Conidium color in the type specimen is dilute tan; Bartholomew noted it as "light brown."

This fungus on *Euphorbia marginata* is not the same species that has been examined recently from *Euphorbia pulcherrima* in Florida, which is:

15. **Alternaria euphorbiicola** Simmons & Engelhard, nom.nov., a substitute for: *Macrosporium euphorbiae* Reichert (1921), Bot. Jahrb. Syst. 56: 723-724. Pl. IV, fig. 8., a later homonym of *M. euphorbiae* Bartholomew (1908); (see no. 14 above). Fig. 28.

Holotype [B]: "*auf Euph. prunifolia, Salamum prope Mansurah. 6.12.1911. S. Schweinfurth.*"; (EGS 09-103).

This fungus, originally collected in Egypt, is readily distinguishable from Bartholomew's fungus collected in the U.S.A. The type of *A. euphorbiicola* was described as having elongate, smooth, pale brown conidia 35-45 x 10-15µm plus a persistent beak 8-12µm long and with 3-6 transverse and 2-4 longitudinal septa. Re-examination of the type specimen indicates a maximum conidium size of about 50-60 x 18-20µm plus a pseudorostrum about 3-30 x 3µm; as many as 6-7 transverse septa and 1-2 longitudinal ones occur in some of the widest central cells of the conidia.

Excellent modern material of this species has originated with Arthur W. Engelhard, Gulf Coast Research and Education Center (University of Florida), Bradenton, as 1-conidium isolates from diseased poinsettia plants. Growth and sporulation of the fungus is excellent on PCA, Hay decoction, and 20% V8-juice agars, at ca. 20C, under a cool-white fluorescent light/dark cycle of 8/16 hrs.

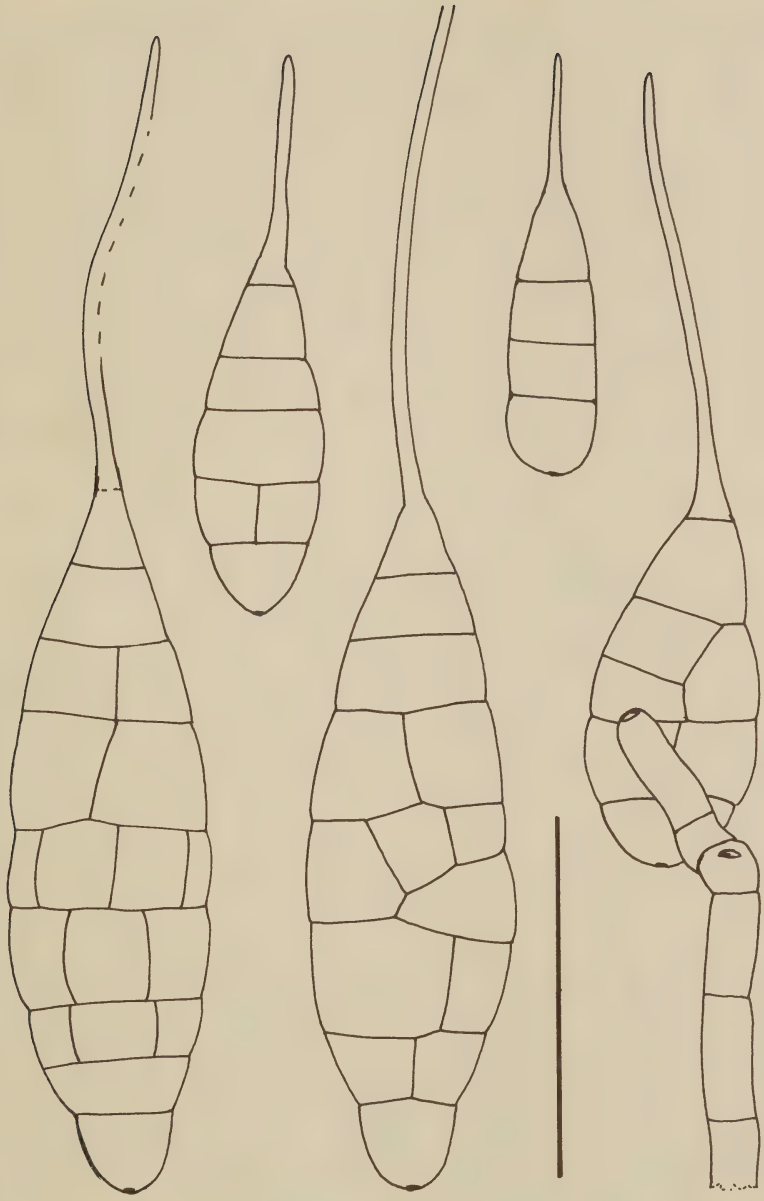

Fig. 27. Alternaria euphorbiae: conidia and conidiophore ex Type. Total length of truncated conidium is 220µm. Magn.: vertical bar = 50µm.

Conidia from 5-day-old colonies on PCA initially are long-ovoid, enlarging to long-ellipsoid and producing as many as six transverse septa in a 60-70 x 18µm spore-body before a longitudinal septum is formed in one of the central cells. Only one (rarely two) longitudinal or oblique septum is produced in 1-4 of the central transverse compartments of a conidium. Conidia lack a definable beak as an entity distinct from the spore-body. In culture, as in the type, the apical conidium cell readily lengthens and becomes converted into a functional conidiophore, a pseudorostrum; chains of as many as 4-5 or more units typically may be produced through this mechanism. Conidia appear to be smooth, pale tan, with well-defined transverse septa and poorly defined longitudinal ones of weak appearance. One of the best of Prof. Engelhard's isolates (no. 6488 = EGS 38-082) is being deposited as "Representative" in major culture collections.

16. **Alternaria angustiovoidea** Simmons, sp. nov. Fig. 29.

Ex culturis in agaris PCA descripta. Coloniae atrae, copiose conidiogenae, mycelio epiagaro raro. Conidiophora recta vel acclivia, simplicia, ex hyphis submersis oriunda, usque 4µm diam. et plerumque ca. 40-60µm longa. Conidia 8-10-longicatenata; juventute proprie anguste ellipsoidea, usque 25-40 x 8µm, aseptata, copiose minute exasperata; maturitate proprie anguste ovoidea vel ellipsoidea, 50-75 x 10-15µm, 3-8 transverse et 1-2 longitudine septata, saepe in medio conspicue constrictiseptata, 50-75(-100) x 4-5µm pseudorostrata. Habitatio typi: in laesionibus Euphorbia esula L., Manitoba, Canada. Typus: partes ex EGS 36-172 (reisol. ex cult. leg. K Mortensen 82-53, 27 July 1982) desiccatae et in [BPI] (holotypus) and pro isotypus saltem in [DAOM], [IMI] et [NY] conservandae.

This third species of Alternaria, which has been received and studied within the past few years as isolates from *Euphorbia esula* (leafy spurge) from Manitoba, Canada, and from North Dakota, U.S.A., originally came to my attention about 30 years ago as a unique morphological entity among a miscellany of 25-30 cultures received from Iowa in 1954 via Lois H. Tiffany. This Iowa isolate (EGS 04-090) was from a "fungus-pad on a tree killed by oak wilt; Forest City, Iowa," and (as a note of surprising coincidence) had been isolated by "A. Engelhard, 8/21/53."

The isolates from leafy spurge have figured in recent publications (J. M. Krupinsky and R. J. Lorenz, 1983; K. Mortensen, 1984). I have been reluctant before now to

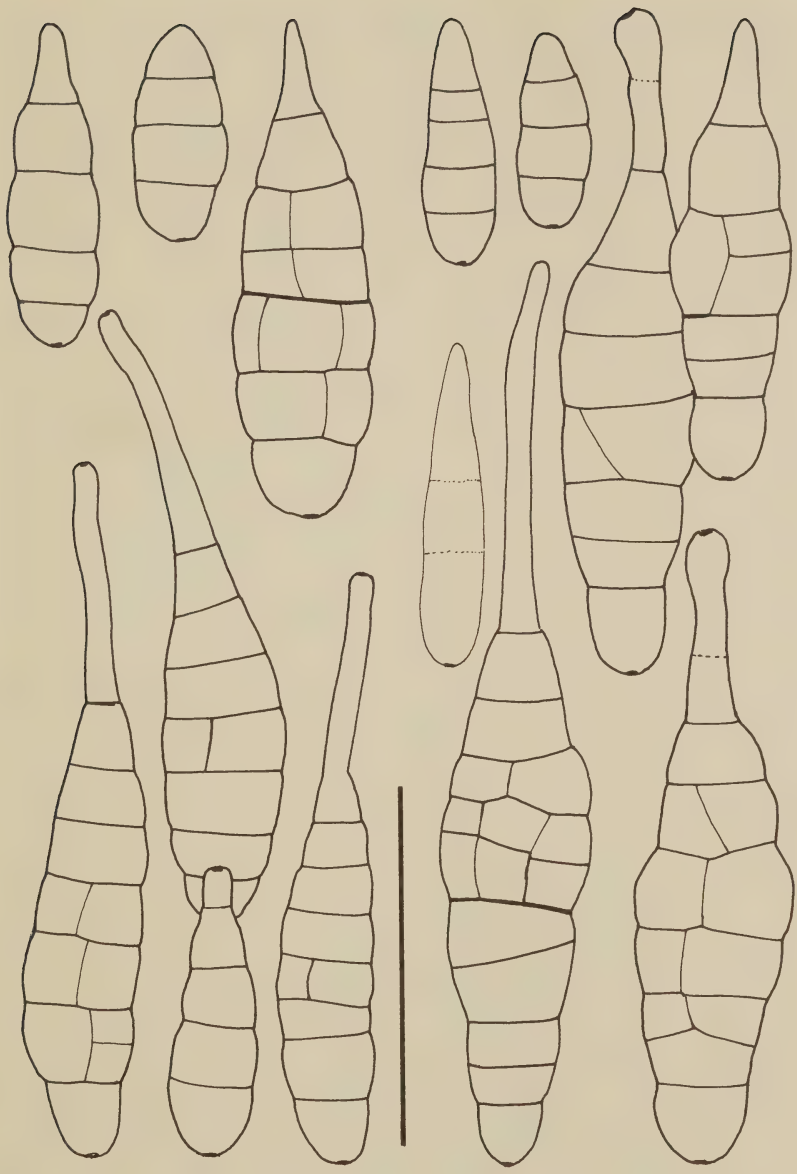

Fig. 28. Alternaria euphorbiicola: at left, conidia ex Type of Macrosporium euphorbiae Reichert; at right, conidia from representative isolate on PCA. Magn.: vertical bar = 50µm.

promote the fungus as an unpublished species, as it has some morphological characteristics of the *A. tenuissima* group, which is a species complex with several members that are recognizable and separable in culture but defiant to attempts at verbal segregation and attachment to published names. The reluctance is abandoned now, as the 1953 fungus-pad isolate matches very well the *Euphorbia*-related isolate from Manitoba, in particular; the North Dakota strain, though identifiable with the others, retains a significant degree of cultural instability after numerous attempts at re-isolation.

Isolates of *A. angustiovoidea* grow and sporulate readily in axenic culture, typically with only a minor amount of non-sporulating aerial mycelium, i. e., the surface colony is composed almost entirely of a dense stand of conidiophores and chains of conidia. Conidium chains usually reach a length of 8-10 units and usually are not branched. The conidium population may exhibit a great variety of shapes, length/width ratios, and septation patterns, as is true in general of chain-forming species of the *A. alternata-A. tenuissima* groups. Typically, however, a very high percentage of *A. angustiovoidea* conidia are strikingly long-narrow-ovoid with numerous transverse and few longitudinal septa and with fairly long pseudorostra.

Narrowly ellipsoid juvenile conidia often are 25-40µm long before a first transverse median septum is formed; 3-8 transverse septa are produced as the conidium ages and one longitudinal septum is produced in each of one or two central cells. The surface of even the youngest conidia may be completely though minutely ornamented; this verrucosity becomes pronounced on older conidia, often becoming dense enough that the pattern of septation is obscured. These diagnostic narrowly ovoid or ellipsoid conidia reach dimensions of ca. 50-75 x 10-15µm, at which point the apical cell of the gradually tapered upper part of the conidium becomes extended into a narrowly cylindrical pseudorostrum 50-75(-100)µm long and produces another conidium.

Sometimes chain formation proceeds so rapidly that only short rostra are produced. Conidia in such chains have a moderately broad ovoid to ellipsoid appearance and their septation may be almost entirely obscured by surface ornamentation, except that the initial median septum usually remains visible. Conidia of all l/w proportions from PCA cultures often have a conspicuous median septum, or it may be unremarkable; those from V-8 culture, however, typically have a strong median septum that is darker, heavier, and more constricting than any of the other septa.

Living cultures equivalent to the type (EGS 36-172) are

Fig. 29. Alternaria angustiovoidea: conidia and conidiophores from representative isolate on PCA. Total length of truncated conidium is 135µm. Magn.: vertical bar = 50µm.

being deposited as "Representative" in major culture collections; this Manitoba isolate was received as [DAOM] 185214 after re-isolation at Ottawa by G. White.

- - o O o - -

The individuals named in the above treatment of three *Alternaria* species on *Euphorbia* have, in their several ways, provided the continuing incentive and balance, the helpful pathology background, and the fresh isolates essential to such a study. The generous support of herbaria and culture collections never can be over-praised, in this case [B], [DAOM], and [NY].

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MYCOTAXON

Vol. XXV, No. 1, pp. 203-216 January-March 1986

ALTERNARIA THEMES AND VARIATIONS (17-21)

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PROLOGUS

In continuation of a series of papers primarily on *Alternaria* (Simmons, 1981, 1982, 1985), herewith are comments on a few species known on *Helianthus*: *A. helianthinficiens* Simmons, Walcz & R. Roberts, sp. nov.; *A. protenta* Simmons, sp. nov.; *A. helianthi* (Hansford) Tubaki & Nishihara; and *A. helianthicola* G. N. Rao & Rajagopalan. Included is comment on the typification of *A. leucanthemi* Nelen, the validating description of which included data on fungi from both *Helianthus annuus* and *Leucanthemum vulgare (= Chrysanthemum leucanthemum)*; lectotypification of *A. leucanthemi* establishes the name as correct for the fungus usually reported since 1965 as *A. chrysanthemi* Simmons & Crosier.

VII. SOME SPECIES OF ALTERNARIA ON HELIANTHUS

A review, currently in progress, of the several species of *Alternaria* described from Compositae hosts/substrates involves approximately 60 epithets published in the period 1838-1985. Some of the pertinent names are widely known but wildly used, in the sense that a morphological concept based on only a few conidium characters of a well-known species often is applied uncritically to disparate material. A good example among compositicolous species is *A. zinniae* M. B. Ellis, a fungus often available in natural condition to anyone with access to a planting of *Zinnia elegans*. Its large, multicellular conidium body with a long filiform beak has become a convenient identification model for somewhat similar fungi on Compositae. However, the model is deceptive, having taken on the nature of a group- rather than species-naming device, for it sometimes fails to account for dissimilar patterns of conidium development, mature morphology, characters in culture, and pathology. (Cfr. Fig. 32, and Simmons, 1982: *Alt.T&V* no. 7, fig. 9-10, *A. zinniae*.)

In 1983 and 1985 several isolates and a quantity of unpublished information on an undescribed *Alternaria* species known only from *Helianthus annuus* were shared with me by Rodney Roberts (USA) and Ilona Walcz (Hungary). The fungus itself had, in fact, been known previously, as it was isolated and considered remarkable as early as 1951 by Mary E. Elliott (Canada), from whom a representative culture was received in 1956. A few other isolates, misidentified as *A. zinniae*, also have been seen.

17. **Alternaria helianthinficiens** Simmons, Walcz & Roberts, sp. nov. Fig. 30 & 32.

Ex culturis in agaris V-8 descripta. Coloniae atrae, mycelio epiagaro inconspicuo, modice conidiogenae. Conidiophora recta vel diverse flexa, simplicia, ex hyphis submersis oriunda, usque ad 200 x 6.5µm. Conidia solitaria, raro 2-catenata; juventute proprie ellipsoidea vel ovoidea; maturitate proprie longiovoidea, apice conoidea, vulgo 68 x 18µm, 7-8 transverse et varie longitudine et oblique septata, 175-200 x 2µm filiforme rostrata. Habitatio typi in semenibus Helianthus annuus L., North Dakota, U.S.A. Typus: partes ex EGS 36-184 (ex cult. R. G. Roberts August 1983 reisol.) desiccatae et in [BPI] (holotypus) and pro isotypus saltem in [DAOM], [IMI] et [NY] conservandae.

The most stable isolates of *A. helianthinficiens* spread somewhat slowly, with only moderate amounts of submerged mycelium and very little surface mycelium (culture conditions: PCA, Hay decoction, 20% V-8 juice agars; ca. 22C.; cool-white fluorescent light/dark cycle 8/16 hrs.). Sporulation occurs on an uncrowded stand of erect, usually unbranched but sometimes geniculate conidiophores. A yellowish red pigment usually is evident under and around colonies growing on V-8 agar.

Conidiophores in colonies 10 days old are up to about 200 x 6.5µm, sturdy but somewhat sinuous, occasionally closely 1-geniculate at sites of conidium production. A single conidium is produced at each conidiophore tip; a second conidium making up a short chain sometimes is produced. Juvenile conidia are ellipsoid, quickly becoming ovoid as the conidium (especially its apical cell) increases in length and constructs its first three transverse septa; conidium dimensions at this stage are about 22 x 8µm. Conidia increase in size and septation, remaining ovoid with a conoid apical cell, and becoming about 68 x 18µm with 7-8 transverse septa and one longitudinal septum in each of 3-4 of the broadest divisions. Most conidia reach this stage of

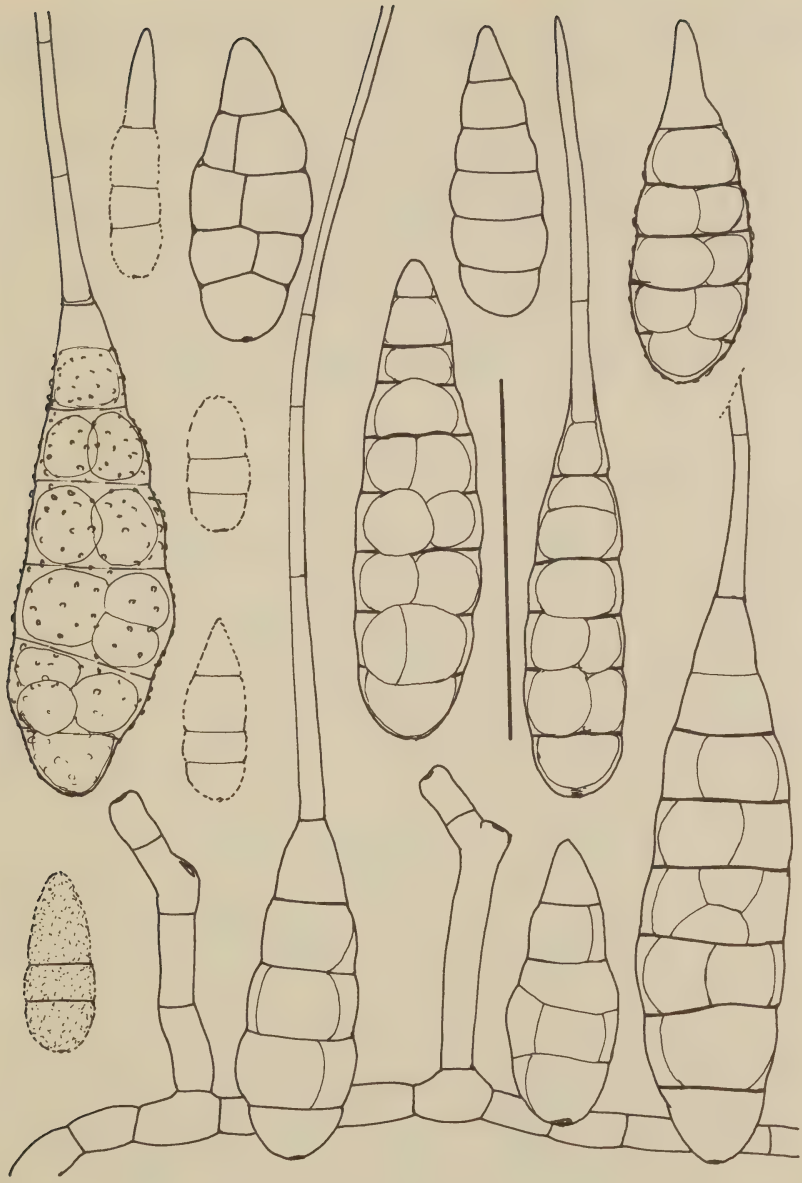

Fig. 30. Alternaria helianthinficiens: conidia and conidiophores ex Type. Total length of truncated conidium at lower left is 170µm. Magn.: vertical bar = 50µm.

size and septation before beginning to produce a long filiform beak that is characteristic of the fully developed spore. Growth of the long filiform beak sometimes is initiated on young conidia, but usually it begins at the tip of a fully formed conidium. It appears at first as a straight, rigid bristle but becomes thin-walled and flexuous as it increases dramatically in length. The point of transition from conidium body to beak (a slight change in color, ornamentation, and wall curvature) is definite, even conspicuous, but without sharp constriction of the wall. It appears that conidia produced on PCA initiate beaks at a slightly earlier stage than do those on V-8 agar. In any case, the fully developed conidium body is about 75 x 20µm with a flexuous filiform beak about 175-200 x 2µm. Major transverse septa usually are 7-8 in number; the central transverse divisions commonly become 2-6-celled when secondary transverse, longitudinal, and oblique septa are produced. Conidium wall color is a medium brown with a hint of green; surface ornamentation is variable but usually discernible, with largest conidia nearly smooth, to minutely rough, to conspicuously verrucose. The internal septation pattern is peculiar and characteristic, in that the primary transverse septa (those that actually adjoin the outer wall) seem to be too weak to restrain individual cells within a strict recto-muriform pattern. The overall impression is of 15-20 small bubbles or balloons (the cell lumina) bulging, crowding, and overlapping within the general confines of the outermost wall. The impression of weakness of the primary septa is supported by the fact that the outer wall of the conidium follows the gentle contours of the cells smoothly rather than being sharply constricted at major cross-septa as often is the case with *Alternaria* conidia.

The 1951 isolate from Canada (EGS 09-166) and several more recent ones (including the type) from R. G. Roberts are from sunflower seed, the former originating in Manitoba and the latter in North Dakota. Isolates made by I. Walcz are from lesions on various parts of living sunflower plants in Hungary.

It has been a fortunate circumstance to have a total of 10 isolates of this fungus for comparison, as decisions to typify new species of *Alternaria* (and other genera) on the basis of ill, parasitized, or unstable solitary strains are missteps already taken too many times in modern literature.

Cultural stability of the 10 strains ranged from nil (for those that became nonsporulating or failed to survive my handling routine); through unreliable (for those able to maintain growth and recognizable sporulation, however erratic, in the presence of internal hyphal parasites); to

excellent (for the type, at least, with its abundant sporulation and absence of alien hyphal elements).

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(Internally parasitized, debilitated strains of *Alternaria* are so common, and ridding them of the alien element is so nearly a hopeless task, that our mycology laboratories, associated disciplines, and culture collection facilities are awash with isolates that may be "typical" or "authentic" - but that certainly are not axenic *Alternaria*. It is depressing to think of the complex and expensive host-susceptibility screening, commercial allergen production, biological control programs, and, not least, teaching and taxonomic opinions that have been and continue to be based on such duplicitous material.)

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18. **Alternaria protenta** Simmons, sp. nov. Fig. 31 & 32.

Conidiophora recta vel flexa, simplicia vel 1-5 geniculate conidiogena, usque ad 110 x 6µm. Conidia solitaria; juventute ellipsoidea, erostrata; maturitate anguste longiovoidea, basi 100-110 x 12-15µm, brunneola, levia vel raro sparsim verruculosa, 125-150 x 2.5µm filiforme rostrata, 10-13 transverse et sparsim longitudine septata. Habitatio typi in laesionibus caulium Helianthus annuus L. Typus: [IMI] 115354b (holotypus), K. Wilson, Mount Makulu, Chilanja, Northern Rhodesia, March 1963; (EGS 24-160, isotypus).

This second previously undescribed *Alternaria* species on *Helianthus annuus* is known from stem lesions in two field collections; it is not yet known in culture. The earlier material is [IMI] 68004, C. G. Hansford 1903, Kampala, Uganda, July 1936 (EGS 22-103); the later and better collection is cited above as type of the species.

Erect, medium brown conidiophores are simple or geniculate at 1-4 conidiogenous sites and about 75-110 x 5-6µm. The conidium body, with light to medium brown wall and major transverse septa, is narrowly long-ellipsoid throughout most of its period of development, matures at about 100-110 x 12-15µm in a length/width ratio of 6.0-8.3. Production of a straight to flexuous filiform beak apparently is initiated after the conidium body reaches a length of about 40-60µm; the beak becomes about 125-150 x 2.0-2.5µm at full size. Fully developed conidia have 10-13 major transverse septa and 1 paler longitudinal septum (rarely 2) in 1-7 of the transverse divisions. Most conidia appear

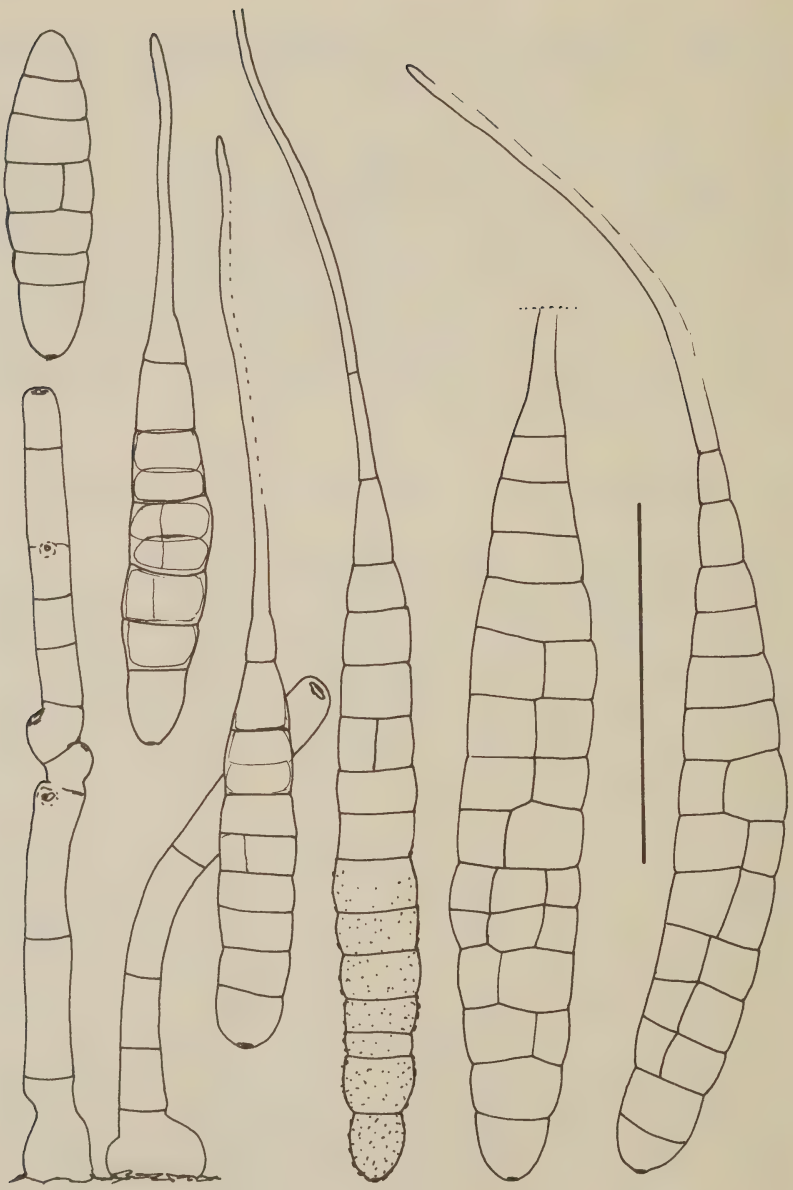

Fig. 31. Alternaria protenta: conidia and conidiophores ex Type. Total length of truncated conidium at left of center is 235µm. Magn.: vertical bar = 50µm.

Fig. 32. Conidium stages to characteristic maturity: left, A. helianthinficiens; center, A. protenta (true juveniles not seen); right, A. zinniae. Magn.: vertical bars = 100µm.

practically smooth regardless of stage of development; the walls of the lowest 2-3 basal cells sometimes are verruculose, and a minor degree of roughness may extend as high as the middle of the spore body, but such evidence of conidium wall ornamentation is rare in the field material seen.

19. **Alternaria helianthi** (Hansford) Tubaki & Nishihara (1969), Trans. Brit. Mycol. Soc. 53: 148; basionym: *Helminthosporium helianthi* Hansford (1943), Proc. Linn. Soc. London 155: 49. Fig. 33 (left).

Holotype [IMI] 5754: "...*Helianthus annuus, Kampala, Uganda, C. G. Hansford 910, March 1928*"; (EGS 27-072).

Alternaria helianthi has become readily recognizable as a parasite of *Helianthus annuus*. Excellent descriptions are in Tubaki and Nishihara (1969) and in M. B. Ellis (1976). Van der Westhuizen and Holtzhausen (1980) have presented an instructive, well-illustrated study of the species, along with definitive comparisons with *"Alternaria chrysanthemi,"* a parasite of *Chrysanthemum* species that sometimes has been confused with the sunflower pathogen.

Briefly characterized, *A. helianthi* conidia, which are erostrate, are much larger than the spore-body portion of *A. helianthinficiens* and *A. protenta* conidia. Only rarely does a conidium produce a short apical or lateral pseudorostrum that functions as conidiophore to a second conidium. Conidia tend to be pale tan in color, long cylindrical to slightly obclavate, obtusely rounded at both ends, smooth, with as many as 10-12 (commonly 5-8) transverse and 1 pale longitudinal or oblique septum (rarely 2) in 1-3 of the major divisions, constricted at septa, as large as 160 x 30µm, but more usually in the range of 75-90 x 20-22µm.

Tubaki and Nishihara (1969), in making the *Alternaria* comb. nov. from *Helminthosporium helianthi* Hansford, queried the identity of the later homonym *H. helianthi* Pavgi (in Pavgi and Upadhyay, 1964), described from a collection MSP253 on leaves of *Helianthus annuus*, Varanasi, U. P., India, Nov. 1961. The Pavgi description may be acceptable within the definition of *A. helianthi*; a few broken conidia(?) seen in the type collection ([IMI] 113117, EGS 30-018) are not in good enough condition for settling the identity question.

Alternaria helianthi has been reported from many parts of the world (cfr. M. B. Ellis, 1976) and is predicted to be found almost anywhere that sunflower is grown. I have been able to verify the identity of the species on material said to originate in Hungary, India, Japan, Malawi, Northern

Rhodesia, South Africa, Tanganyika, Uganda, USA (Mississippi, North Dakota), and USSR. The isolate from Hungary (EGS 38-074) is culturally stable and representative, as are several others.

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Nelen (1962), in describing *Alternaria leucanthemi*, included conidium measurements of fungi from parts of two different hosts, namely, stems of *Helianthus annuus* L. and leaves of *Leucanthemum vulgare* Lam. (= *Chrysanthemum leucanthemum* L.); he cited the two sets of measurements separately, illustrated conidia from the two hosts independently, discussed their differences, and specified material on *Leucanthemum vulgare* as "(typus)."

Many of Nelen's *Alternaria* types have been received for examination, but the *A. leucanthemi* specimen on *Chrysanthemum* has not; I assume it is lost. The fungus on *H. annuus* is *A. helianthi* (EGS 20-164), ex [LE] "[*on stems of Helianthus annuus L., Far East Primorski Krai...Vladivostok...19 IX 1952, leg./det. E. S. Nelen*]." Nevertheless, Nelen's description and illustrations of the fungus from *Chrysanthemum* are so good, his comparison of it with the fungus from *Helianthus* is so nearly coincident with those made by other authors, and my familiarity with a multiplicity of material representing, I believe, the same two species is comprehensive enough that the following conclusion is reached:

20. **Alternaria leucanthemi** Nelen (1962), Bot. Mater. Gerb. Bot. Inst. Kamarova Akad. Nauk SSSR 15: 148-150.
Fig. 33 (right).

Lectotype: Nelen, l. c., description and illustration [cfr. ICBN, 1983: Art. 9.3]: "*Conidia...26-105 x 10-12μ.... In foliis Leucanthemi vulgaris Lam....Vladivostok...20 IX 1955 (typus)*," and Nelen's fig. 6 & 8; specifically excluded are the fungus on *Helianthus annuus*, descriptions of its conidia, and the related fig. 7.

The erratic name-publishing history of the fungus is:

1957 *A. chrysanthemi* Crosier & Heit (invalid, lacking Latin and type designation)
1958 *A. chrysanthemi* Schmidt (invalid, lacking Latin)
1959 *A. leucanthemi* Nelen, in Nelen and Vasilyeva (invalid, lacking Latin and type designation)
1962 *A. leucanthemi* Nelen (valid publ., now lectotypified)
1965 *A. chrysanthemi* Simmons & Crosier, in Simmons (taxonomic synonym of *A. leucanthemi* Nelen).

Briefly characterized, *A. leucanthemi* conidia are similar to those of *A. helianthi* in that they typically are large, long cylindrical to long obclavate, smooth, completely erostrate, and have numerous transverse septa. *A. leucanthemi* conidia generally reach a size range of about 75-105 x 20-30µm, with maximum lengths up to 130-160µm; form as many as 15-17 transverse and few or no longitudinal septa in field material but variable numbers of secondary transverse, oblique, and longitudinal septa in the wider transverse divisions; develop medium or darker olive-brown wall and septum color (in contrast to the paleness of *A. helianthi* conidia). Conidia produced on Hay agar tend to mature in an obclavate shape, with most of the secondary septation concentrated in the lower half of the spore; conidia produced on PCA and V-8 agars develop secondary septation in their widest transverse divisions, which occur in almost any position throughout the length of the spore. Pseudorostra and secondary conidia are extremely rare; they originate just as frequently from basal or intercalary conidium cells as they do from the apex.

Some *A. leucanthemi* isolates do not sporulate readily in culture; I probably now would spurn as unreliable the isolate QM 7227 (EGS 10-059) used in typification of *A. chrysanthemi* Simmons & Crosier. The best isolate of the species that I have handled is from a diseased leaf of Shasta daisy (*C. maximum*) received from Florida, USA, via E. K. Sobers in May 1964 (EGS 17-063 = QM 8579). It still sporulates profusely under my culture conditions and has very little tendency to produce non-sporulating aerial mycelium. Assuming similar stability elsewhere, it is a good representative and already is on deposit in major international culture collections (e. g., CBS 422.65).

Assuming correct identification of the type host *Chrysanthemum leucanthemum* (= *Leucanthemum vulgare*), the only other known host is *C. maximum* Ram. (= *L. maximum* (Ram.) DC.). A report of the species on *C. indicum* L. (V. G. Rao, 1965) describes and illustrates a fairly long-beaked *Alternaria* species quite different from *A. leucanthemi*.

Sobers (1966) made extensive attempts to induce infection of representatives of other genera of Compositae and other plant families, but was not successful.

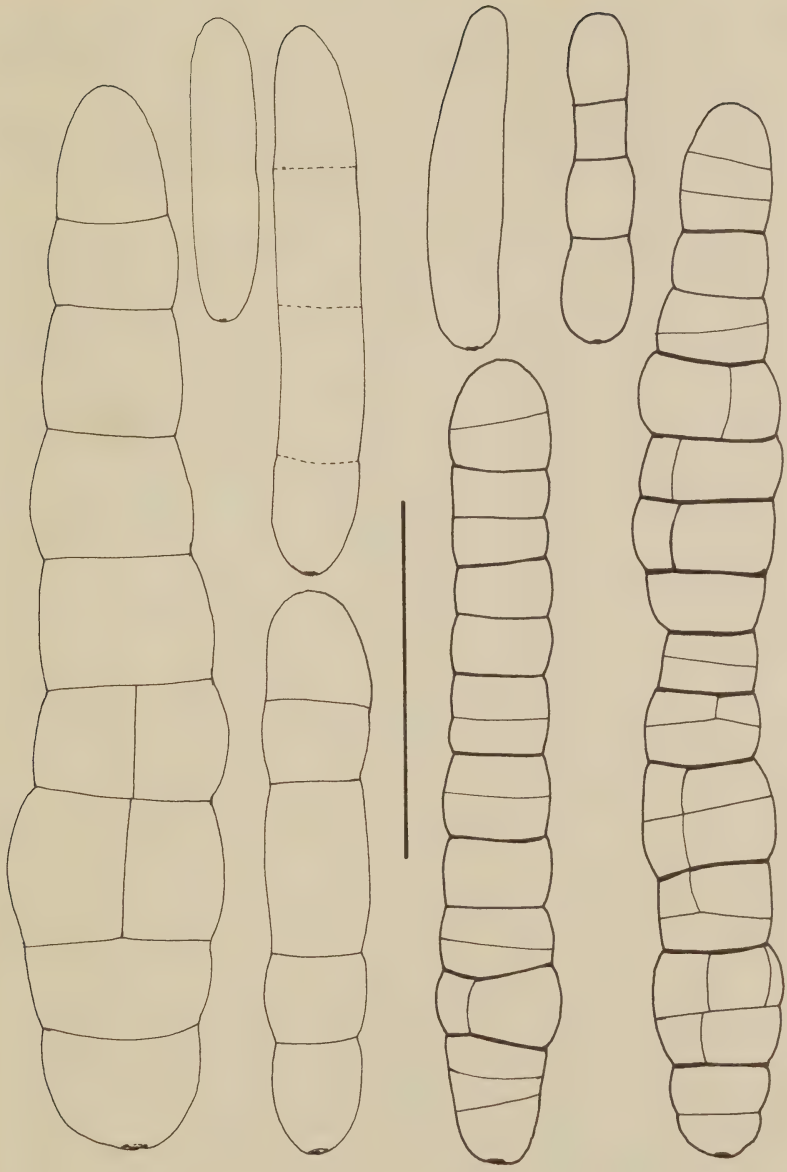

Fig. 33. Conidia and conidiophores ex representative cultures of (left) Alternaria helianthi and (right) Alternaria leucanthemi. Magn.: vertical bar = 50µm.

21. **Alternaria helianthicola** G. N. Rao & Rajagopalan (1977), Current Science 46: 750. Fig. 34.

Holotype: [IMI] 191573, a dried-down preparation derived from the "type culture," received as an isolate from "*Helianthus annuus, Tirupati, Andhra Pradesh, India, J. Subbayya 12.2.1975.*"; (EGS 38-120).

The type material is of an *Alternaria* species having comparatively small conidia produced in chains through the agency of prominent pseudorostra. The authors give an average overall conidium length of 66.5µm, of which the average beak length accounts for 45.5µm. The longest conidium body I have seen in the type is 50 x 12µm; most are in the 30 x 10-12µm range; large numbers of conidia are quite small, 10-20 x 6-10µm, yet bear apical and/or lateral pseudorostra that are short and simple or that may be as long as 100µm and at least 7-geniculate, branched, and conidiogenous. Conidia become moderately to dark brown and are smooth to markedly verruculose; septation may be up to 8 transverse with 1-2 longitudinal or oblique in 1-3 of the transverse divisions; the great majority of conidia, however, have only 0-4 transverse and 0-1 longitudinal or oblique septa.

This information, set against a template of observations on much similar material in culture, makes it possible to reconstruct the sporulation pattern that existed before the conidium chains were disrupted: an erect conidiophore topped by a single relatively large conidium with a 1-2-geniculate pseudorostrum; a new smaller conidium at each geniculation, each conidium pseudorostrate with the beak elongating, sometimes branching laterally, and producing a single conidium or sometimes a short, branching chain of small conidia. The final picture is of a bushy, branching, decidedly 3-dimensional clump of variously contorted aerial conidiophores and their conidia.

This picture is that of a group of *Alternaria* species similar to one that we now are calling "*Alternaria* state of *Pleospora infectoria*," and with which *A. helianthicola* may be identical. I believe, after examining scores of similar isolates, that we are encountering a group of related species rather than a single catchall anamorph. Work on characterizing these species currently is in progress. No further comment on *A. helianthicola* is desirable here except to note that the species does not in any way (except generically) resemble the large-spored helianthicolous species discussed in *Alt.T&V* no. 17-19 above.

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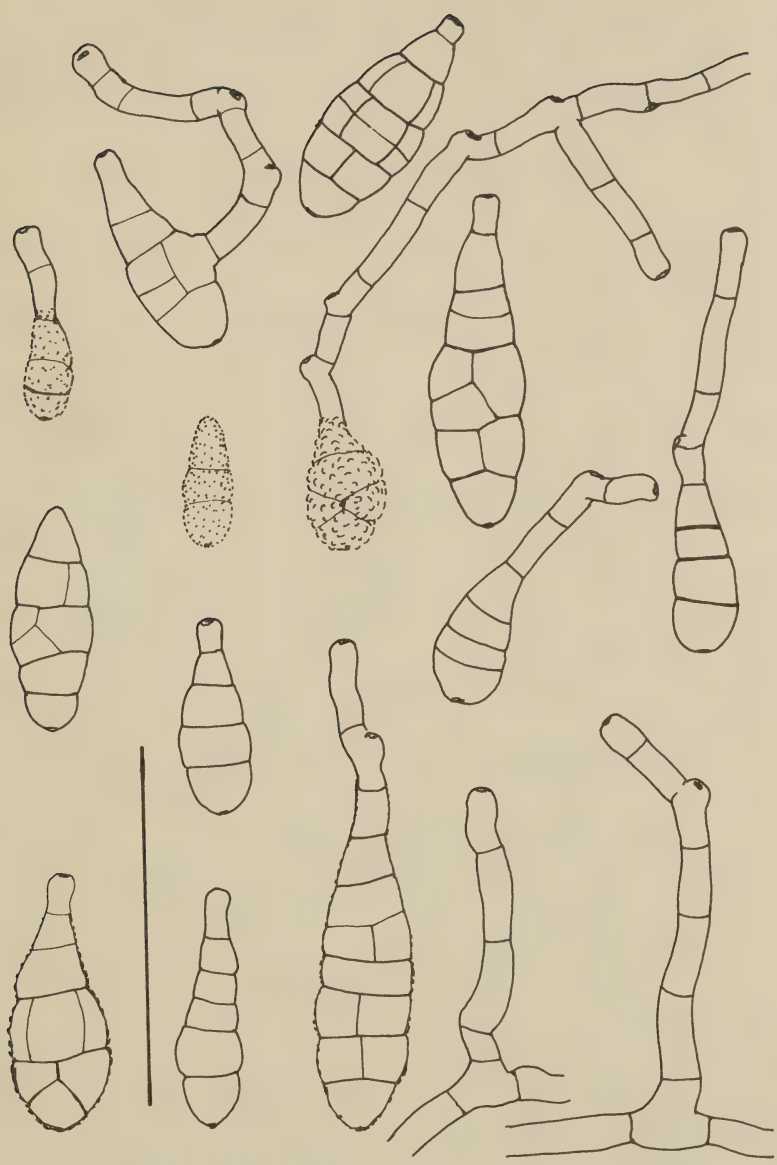

Fig. 34. Alternaria helianthicola conidia and conidiophores ex Type. Magn.: vertical bar = 50µm.

It has been a pleasure to cooperate with Ilona Walcz and Rodney Roberts in this study. Dr. M. E. Barr Bigelow kindly has helped me to avoid traps of syntax and taxonomic presentation by editing the manuscript. Support of [DAOM], [IMI], and [LE] is acknowledged with gratitude.

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MYCOTAXON

Vol. XXV, No. 1, pp. 217-227 January-March 1986

GLOMUS MACULOSUM SP. NOV. (ENDOGONACEAE): AN ENDOMYCORRHIZAL FUNGUS

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SUMMARY

A new species of *Glomus* is described and named *Glomus maculosum*. The fungus is characterised by spores which have a distinct 'endospore' formed by an inner, membranous wall that may invaginate and thicken in places to appear as if covered by 'spots' when viewed with low-power microscopy. The fungus forms endomycorrhizae with apple, sorghum, and probably with coleus.

INTRODUCTION

A survey of endomycorrhizae in apple (*Malus domestica* Borkh.) (Miller, Domoto and Walker 1985) yielded an undescribed species of *Glomus* Tul. and Tul. from an orchard in Door County, Wisconsin. Spores of this fungus were originally discovered in sievings of soil collected in the survey, and open pot cultures (Gilmore 1968) were established from unsieved soil with sorghum (*Sorghum sudanense* (Piper) Staph.) and coleus (*Coleus x hybridus*) as host plants. It was later isolated in single-species ('pure') pot culture with sorghum and apple. Observations on germination were made from spores surface-disinfested with Chloramine-T and plated out on water agar. Descriptions of walls in this paper, and the presentation of the standardized murograph (Figure 1) are those proposed by

Walker (1983). Colors used in the description correspond with those in the Flora of the British Fungi color identification chart (Anon 1969).

GLOMUS MACULOSUM Miller et Walker sp. nov. Figures 1-3.

Sporae singillatim in terra enatae, globosae vel subglobosae, (95-)135-178(-220) x (95-)130-187(-220) µm, pallide stramineae vel ochraceae maturescentes, laeves. Tunica sporae stratis tribus: exteriore 0.3-1.0 µm crasso, hyalino, adhaerenti; medio 4-13 µm crasso, pallide stramineo vel ochraceo, lamellato; interiore membranaceo, tenui, maturitate separabili, in sporis veteribus inauctos tholiformes, pectinatos ferenti. Hypha affixa strato medio tunicae sporae concolora, recta vel acute recurva, simplex, infundibuliformis vel constricta ad basim sporae, 5-13 (-25) µm longa, 5-7 µm crassa ad coniunctionem hypha parentali, hyalina, tenuitunicata. Sporae per hypham affixam germinantes.

SPOROCARPS unknown. SPORES formed singly in the soil on one to three subtending hyphae; hyaline when immature, becoming pale straw-colored to ochraceous when mature, globose to subglobose, (95-)135-178(-220) x (95-)130-187 (-220) µm.

SPORE WALL STRUCTURE of three walls (walls 1-3) in two groups (groups A and B). Wall group A of an outer, thin, hyaline, unit wall (wall 1), 0.3-1.0 µm thick, tightly adherent to wall 2, a brittle, pale straw-colored to ochraceous, laminated wall, 4-13 µm thick, with 4-16 laminae, the innermost lamina sometimes appearing to be a separate, unit wall, and often forming a septum at the spore base. Inner wall group (group B, wall 3), membranous, very thin (<0.3 µm) and tightly adherent to wall 2 in young spores, but becoming 0.5-1 µm thick and separating readily as the spore ages. Wall 3, in many older spores, bearing domed, scalloped ingrowths, 6-15 µm diameter and up to 12 µm deep, consisting of 2-8 concentric bulging discs increasing in diameter towards the inside of the spore.

SUBTENDING HYPHA concolorous with spore wall 2, straight to sharply recurved, parallel-sided, or funnel-shaped, sometimes constricted at the spore base, 5-13(-25) µm long, 5-13 µm wide proximally, and 5-7 µm wide at the point of connection to a thin-walled, hyaline parent

hypha. Many spores appearing sessile due to breakage of the subtending hypha at the constriction. Walls of subtending hypha 1.5-3 µm thick proximally, tapering distally to 1 µm.

SPORE CONTENTS (Figure 2A-D) of crowded oil droplets, often appearing reticulate in optical section. On crushing, spores exude liquid with the appearance of oil, sometimes accompanied by fibrous material, especially in those spores that appear reticulate (Figure 2A).

Young (hyaline) spores are cyanaphilous in cotton blue. Older spores either are acyanaphilous or become yellowish-green in this dye due to wall 3 staining more readily than wall 2. The spores have no reaction to Melzer's reagent. The spores immediately turn sienna on immersion in 1N KOH.

The spores germinate through the subtending hypha, often by a side-branch. Septa form in the germ hyphae near the spore, but the hyphae then become increasingly sparsely septate upon rapid elongation.

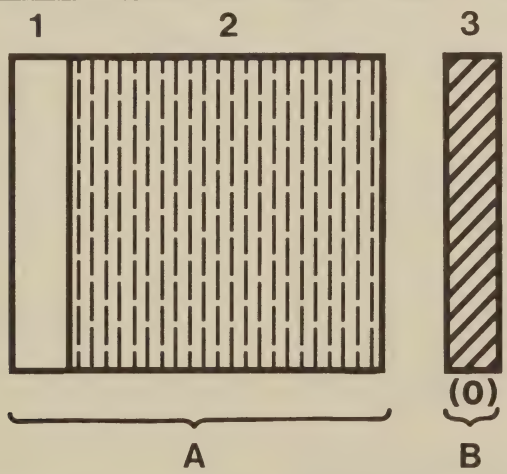


Figure 1: Murograph of *Glomus maculosum* (after Walker 1983). Spore wall structure is of three walls in two groups and consists of a unit wall (no shading) adherent to a laminated wall (dashed shading) surrounding a membranous wall (diagonal shading). Wall 3 may be ornamented.

Figure 2: Spores of *Glomus maculosum* showing spore contents and development of ornamentation of the inner wall.

A: A young spore lacking indications of scallop-shaped ingrowths. The membranous wall (wall 3) is tightly adherent to wall 2, but can be seen where the spore is broken (arrow). The fibrous nature of the spore contents can be seen (f) and an oil droplet has exuded at upper right.

B: A slightly older spore than that shown in 2A. The beginnings of ingrowth formation are evident as slight invaginations of wall 3 (arrowed). Oil droplets from the spore contents have exuded where the spore is broken.

C: At a more advanced stage of ingrowth formation, deposits of wall material are laid down on wall 3 at the points of invagination.

D: In this specimen, splits have appeared between the laminae in wall 2.

E: In this mature specimen, ingrowth formation is complete. The subtending hypha of this spore has broken off (top), rendering the specimen sessile.

F: Micrograph (brightfield microscopy) showing the 'spotted' appearance caused by the ingrowths on wall 3 in a mature spore.

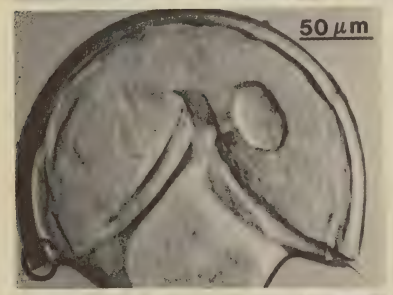
G: Photomicrograph showing the appearance of the spots on the same specimen as in Figure 2F under Nomarski differential interference microscopy (DIC).

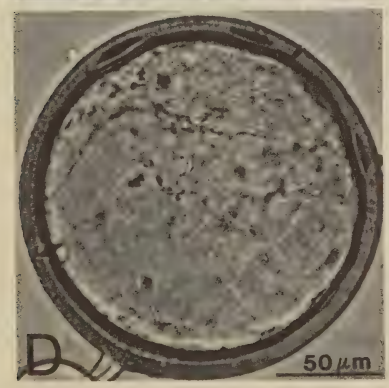
H: Details of the wall structure of a mature spore of *G. maculosum*. The laminated nature of wall 2 and the membranous nature of the ornamentation of wall 3 are evident (DIC).

I: Detail of the wall structure of a *G. maculosum* spore. The three walls, Wall 1, a unit wall (u), wall 2 a laminated wall (l) and wall 3 the inner, membranous wall (m) and its ornamentation of ingrowths can be seen in this specimen.

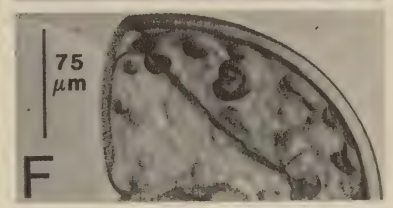
A
50 µm

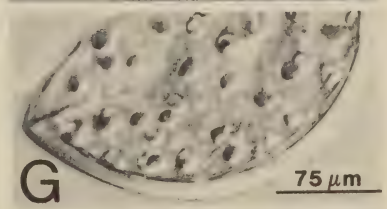
50 µm
B

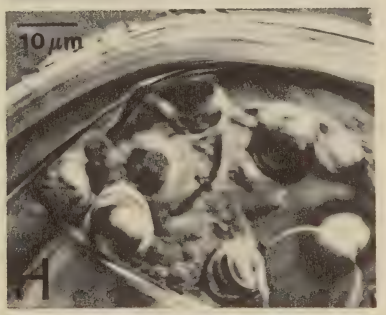

50 µm

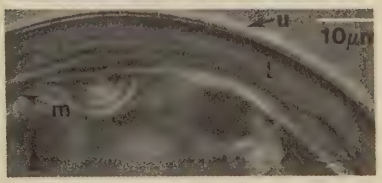

D
50 µm

E
25 µm


75
µm
F


G
75 µm


10 µm
H


u
10µm
l
m

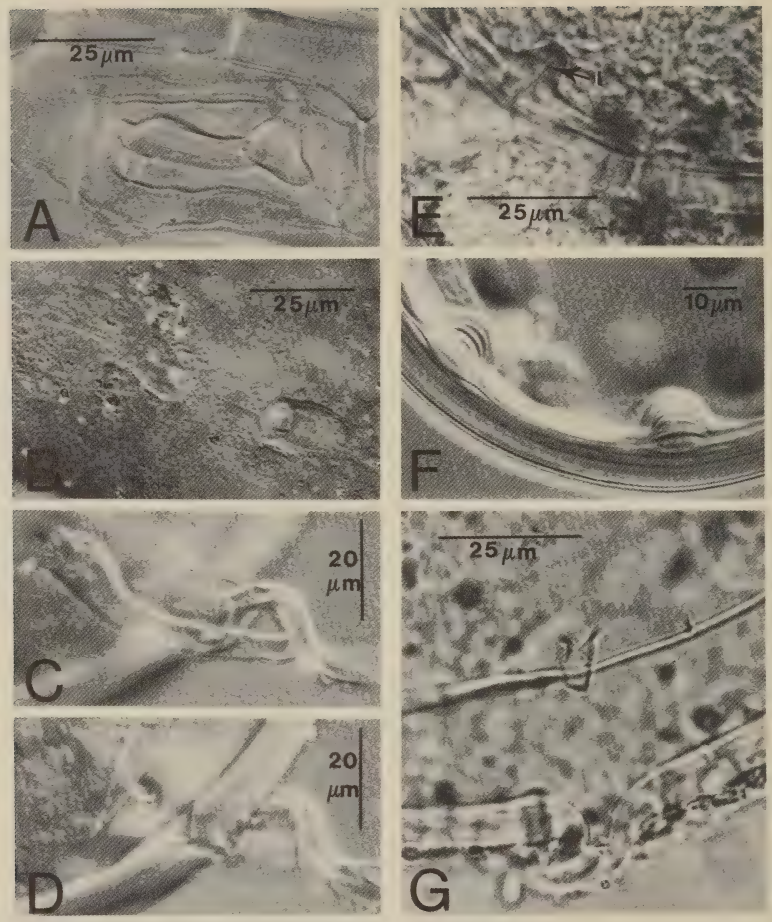

25 μm
A
25 μm
B
20 μm
C
20 μm
D
E
25 μm
10 μm
F
25 μm
G

Figure 3: *Glomus maculosum* mycorrhizal structure and details of chlamydospores.

A: Hyphal coil in root of apple seedling photographed by Nomarski differential interference microscopy (DIC).

B: Photomicrograph (DIC) showing two subtending hyphae attached to a *G. maculosum* spore.

C-D: Photomicrographs of a spore with two subtending hyphae joined to a single originating hypha. The two photographs are taken at different levels of focus in order to show both connections with the spore.

E: Tubiform ingrowths on a parasitized spore. The lumen of these ingrowths can be seen penetrating the spore wall (1).

F: Detail of the scalloped ingrowths ornamenting the inner wall of a *G. maculosum* spore. There is no evidence of invasion by parasitic organisms, and the ingrowths do not possess a lumen.

G: This photomicrograph shows the closure of the subtending hypha at the pore, and the way wall 3 forms a complete endospore.

DISTRIBUTION AND HABITAT

This species is known from one field location. It was isolated from soil samples collected on 30 July 1980 from under newly established apple trees at the Peninsular Experiment Station of the University of Wisconsin, Sturgeon Bay, Wisconsin (Miller, Domoto and Walker, 1985). The soil was Longrie silt loam (coarse-loamy, mixed, frigid Entic Haplorthods) (Anon, 1975); pH 6.6; the soil nutrient status was (mg kg^{-1}): P = 65, K = 124, Ca = 1120, Mg = 248, Mn = 13, Zn = 4.8, B = 1.6, with a cation exchange capacity of 9. Apple trees were the only cultivated crop present at the site when the original soil sample was collected. The land had lain fallow for the preceeding 2 years and although there was some weed control by mechanical cultivation, many weed species were present to provide a source of initial inoculum.

MYCORRHIZAL ASSOCIATIONS

Glomus maculosum has formed endomycorrhizae with apple and sorghum, in pure culture, and also was found with other members of the Endogonaceae in pot culture with

coleus. The endomycorrhizae are not typical, neither vesicles nor arbuscules having been detected. They consist of isolated hyphal coils, filling cortical cells (Figure 3A). Numerous attempts to stain the mycorrhizas with normal methods using trypan blue, cotton (analine) blue and acid-fuchsin red, failed to reveal the fungus, and it was not until cleared roots were carefully examined with Nomarski Differential Interference Microscopy that the mycorrhizas were observed. It is possible that the extended bleaching period needed to clear the heavily-pigmented apple roots (Miller et al, 1985) rendered the hyphal structures unstainable and destroyed delicate structures such as arbuscules.

ETYMOLOGY

Latin - *maculosum,* spotted, referring to the appearance caused by the scalloped ingrowths on the membranous inner wall of older spores.

COLLECTIONS EXAMINED

Holotype: WISCONSIN, Door County, Peninsular Experiment Station, University of Wisconsin, Sturgeon Bay, among roots of apple trees. Type specimens (OSC, isotype K) from a pot culture with sorghum and coleus in the Horticulture Department Greenhouses, Iowa State University, Ames, Iowa (Walker collection number 505, 26 January 1982) made from soil collected at the type locality. In addition, specimens from pure pot cultures with apple and sorghum were examined (Walker 531, 22 April 1982; Walker 568, 15 June 1982; Walker 765, 30 January 1983).

DISCUSSION

The most distinctive feature of *Glomus maculosum* chlamydospores is the scalloped thickening of the inner membranous wall. This characteristic is not present in young spores (Figure 2A). It begins with a slight invagination of wall 3 (Figure 2B, 2C), sometimes accompanied by localised separation of the laminae in wall 2 (Figure 2D). After initiation, there seems to be a very rapid deposition of the scalloped layers to form the structures that appear as 'spots' at relatively low magnification (Figure 2F, 2G), since spores seem to be mostly either without spots, with only primordial invaginations, or with fully developed structures (Figure 2E-I) of

several layers. The frequency of spores with the spots increases with age of pot culture. Those harvested for spores after 7 months contained a majority of spores with the structures, whereas if harvested in less than 4 months, they contained spores either without them, or with the primary invaginations only. In all pot cultures, some spores can be found that appear mature, but which lack spots.

Light microscopy (up to 2000X) of the spots has given no hint of parasitism as a cause. Some specimens attacked by parasites showed a normal reaction of tubiform ingrowths as reported by Mosse and Bowen (1968). The lumen of these ingrowths invariably penetrates the spore wall (Figure 3E), whereas the scalloped structures found on wall 3 of *G. maculosum* spores never shows evidence of penetration or other attack (Figure 3F). Pure pot cultures which produced spotted spores were started from spores which had been surface disinfested by immersion for 7 min in a solution of 3% Chloramine T with with 500 $\mu g\ l^{-1}$ Streptomycin. The addition of spotted *G. maculosum* spores to pot cultures did not result in the transfer of the characteristic to other endogonaceous species.

Glomus maculosum is mainly distinguished from previously described similar *Glomus* species by the characteristics of its spore walls. In particular, no other *Glomus* is described as having an inner, membranous wall forming a complete endospore (Figure 3G), and no other species in the genus possesses the ingrowths on the inner spore wall.

Spores of *Glomus etunicatum* Becker and Gerd. are of somewhat smaller average size than those of *Glomus maculosum* (68-162 µm diameter compared with 95-220 µm) and have a different wall structure. Spores of the former have two walls; a hyaline, evanescent, outer wall up to 5 µm thick overlaying a yellow to brown laminated wall 2-8 µm thick, whereas those of the latter have three walls; a thin, hyaline, unit wall up to 1 µm thick attached to a pale, colored laminated wall, 4-13 µm thick that surrounds a membranous wall up to 1 µm in thickness. In older spores, wall 3 of *G. maculosum* is very distinctive, especially when it becomes ornamented with the characteristic scallop-shaped ingrowths. Young spores of *G. etunicatum* and *G. maculosum* are similar in color, but as the spores mature, in the former species they darken and

become brown, whilst in the latter they remain rather pale, and do not become brown.

Some spores of *G. maculosum* have multiple hyphal attachments (Figure 3B-D), a characteristic feature of *Glomus multisubstensum* Mukerji et al., a species described from India. Requests for the loan of specimens of this fungus made to both the senior author and the herbarium at Delhi have been ignored, and we therefore have been unable to make direct comparisons. Nevertheless, the description of the latter indicates that these species have little else in common, size range, color, and wall structure all being different.

Spores of *Glomus geosporum* (Nicol. and Gerd.) Walker are of a similar size range to those of *G. maculosum*, but are much darker in color (light yellow-brown when young becoming dark brown at maturity). Superficially, the wall structure of these two species appears the same, but while the inner wall of the former is a colored, unit wall, not separating from the middle wall, wall 3 of the latter is hyaline, membranous, and in a separate wall group. Additionally, the subtending hypha of *G. geosporum* is persistent and extends 30-100 µm beyond the spore base, whereas that of *G. maculosum* usually extends little more than 5 µm distally and often is broken away completely.

Glomus versiforme (Karst.) Berch and Fortin is of similar spore size to *G. maculosum*, and young spores of these species may be similar in color. However, spores of the former have only two walls in a single group, whilst the latter has spores with three walls in two groups. Wall 3 of *G. maculosum* is apparent even on immature spores.

ACKNOWLEDGEMENTS

We wish to thank Dr. J. M. Trappe, USDA Forest Service, for the Latin diagnosis and for reviewing the manuscript. We also thank Annelise Green, Forestry Commission, for assistance in preparation of this publication.

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MYCOTAXON

Vol. XXV, No. 1, pp. 229-245 January-March 1986

FOUR NEW JAPANESE SPECIES OF THE CERATOSTOMATACEAE (ASCOMYCETES)

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Key Word Index ----- *Arxiomyces*; *Persiciospora*; *Sphaerodes*; *Syspastospora*; Ceratostomataceae; Melanosporaceae; soil fungi; Japan

SUMMARY

Four new species of the Ceratostomataceae, isolated from cultivated and forest soils in Japan, are described and illustrated: *Arxiomyces campanulatus*, *Persiciospora japonica*, *Sphaerodes micropertusa* and *Syspastospora boninensis*. They are compared with similar species of their respective genera.

Classification of the Ceratostomataceae Winter (syn. Melanosporaceae Bessey (Cannon & Hawksworth, 1983a)) is difficult because superficially similar ascomycetes have undoubtedly been derived from a number of unrelated sources through convergent evolution. This can be illustrated by comparing, for example, *Melanospora* Corda, *Ceratocystis* Ellis & Halsted and *Microascus* Zukal; most species in these genera having ascomata with long necks, often with terminal hairs, and evanescent asci. Each of these features is an

adaptation for passive dispersal of ascospores, through water-splash or animal contact, rather than by active discharge into air currents. The three genera mentioned above have long been treated separately, and are now regarded as belonging to different orders (Hawksworth *et al.*, 1983). There are, however, a number of groups of superficially similar fungi that have recently been classified close to or within *Melanospora* (*nom. cons. prop.*; Cannon & Hawksworth, 1983b), such as *Scopinella* Lév. and *Sphaeronaemella* P. Karsten, which are now thought to be distantly related. *Melanospora* itself as currently constituted is probably monophyletic, but the relationship of this genus to similar ones, such as *Sphaerodes* Clem., *Syspastospora* P. Cannon & D. Hawksw. and *Arxiomyces* P. Cannon & D. Hawksw. is not yet clear. The relationship of the Ceratostomataceae to the Chaetomiaceae is also not properly understood, and genera such as *Canariomyces* von Arx (1983) defy appropriate placement.

Particular note must be taken of characters which are unlikely to be subject to strong selection pressures, since these are more likely to reflect the true relationships of fungi than are ecological or nutritional similarities (though these features may of course be taxonomically significant). Characters such as the number and form of germ pores, ornamentation of ascospores and structure of ascomatal walls should be emphasised in classification of the Ceratostomataceae. The most recent account of the group (Cannon & Hawksworth, 1982), which drew on a number of earlier works (e.g. Udagawa & Cain, 1969; Malloch, 1976a,b; Hawksworth & Udagawa, 1977; von Arx, 1981), used these features in the establishment or reestablishment of several genera. In treating *Microthecium* Corda as a synonym of *Melanospora*, however, previous emphasis on cleistothecium versus perithecium as a generic criterion was rejected. Once used to separate classes and orders, this feature is now considered to be of minor significance, sometimes varying within a single isolate of a species.

The current emphasis on micromorphology of ascospores in classification of the Ceratostomataceae may, in time, be supplemented by other characters (perhaps data from the analysis of secondary metabolites). The present delimitation of genera seems, however, generally satisfactory and may well reflect the true relationships of the taxa concerned.

During the past decade *Melanospora*-like ascomycetes have been isolated repeatedly from soil samples collected in several parts of Japan. Only a few species of *Melano-*

spora and allied genera have been reported previously from Japanese soil (Hawksworth & Udagawa (1977), Horie & Udagawa (1973), Udagawa (1965,1970), Udagawa & Cain (1969), Udagawa & Takada (1974)) and attempts to assign them to previously described members of the family have been largely unsuccessful. Recently, the report on re-evaluation of *Melanospora* Corda and similar Pyrenomycetes by the junior author and Hawksworth (1982) prompted the taxonomic investigation of the additional isolates from Japan. During the course of this four new species have been encountered: *Arxiomyces campanulatus*, *Persiciospora japonica*, *Sphaerodes micropertusa* and *Syspastospora boninensis*.

Arxiomyces campanulatus Horie, Udagawa & P. Cannon, sp. nov. (Figs. 1, 5)

Perithecia superficialia vel semiimmersa, dispersa vel in catervis parvis aggregata, atrobrunnea vel fere nigra per massam ascosporarum, basi globosa, 160–200 µm diam, glabra vel parum pilosa; collum dilute flavo-brunneum, cylindricum, 70–190 x 40–70 µm, ad apicem expansum, 'textura globulosa' vel 'textura angularis', ex cellulis 8–15 x 4–6 µm composito. Peridium flavo-brunneum, 12–20 µm crassum, membranaceum, bistratum; stratum exterius 'textura angularis', ex cellulis flavo-brunneis, 8–20 µm diam composito; stratum interius ex cellulis hyalinis. Asci vulgo tetraspori, late clavati vel obpyriformes, 12.5–18 x 7.5–10 µm, brevistipitati, celeriter evanescentes; paraphyses indistinctae. Ascosporae primo hyalinae et tenues, deinde modice brunneae vel valde olivaceo-brunneae, in massa fere nigrae, ovoideo-ellipsoideae, (5–)6–7 x 4–5 µm, basi truncatae, apice rotundatae, leves, cum (uno) poro germinali basali praeditae, 2–2.5 µm diam.

Holotypus ----- isolatus e solo sativi cum *Stachybotrys chartarum* (Ehrenb.) Hughes, Ohwadashinden, Yachiyoshi, Chiba, in Japonia, 28.ix.1975, legit. Y. Horie, No. 2918. In Herbario NHL. Isotypi: IMI 281910, IFM 4612.

Etymology: Latin, *campanulatus* = campanulate, referring to the ascospore shape.

Perithecia superficial to semiimersed, scattered or aggregated in small clusters, dark brown to nearly black due to spore mass, base globose, 160–200 µm diam, glabrous or slightly hairy; neck pale yellowish brown, cylindric, 70–190 x 40–70 µm, flared at the tip, composed of slightly elongated vertically oriented *textura globulosa* to *textura angularis* with cells 8–15 x 4–6 µm in size. Ostiolar setae absent. Peridium yellowish brown, 12–20 µm thick, membra-

naceous, two-layered, the outer layer consisting of yellowish brown, *textura angularis* with cells measuring 8–20 µm diam, the inner layer hyaline. Asci usually 4-spored, broadly clavate or obpyriform, 12.5–18 x 7.5–10 µm, without apical structure, short-stipitate, quickly evanescent; paraphyses indistinct. Ascospores at first hyaline and thin, becoming mid-brown to dark olivaceous brown, nearly black in mass, ovoid-ellipsoidal, (5–)6–7 x 4–5 µm, base truncate with a hyaline, often collapsed appendage, apex rounded, smooth-walled, with a single large basal germ pore, 2–2.5 µm diam. Anamorph not observed.

Cultures on cornmeal agar, with *Stachybotrys chartarum* (Ehrenb.) Hughes, developing gradually, producing abundant perithecia within 28 days at 25 C.

Isolation: on *Stachybotrys chartarum* in mixed culture from cultivated soil, Ohwadashinden, Yachiyo-shi, Chiba-pref., Japan, 28.ix.1975, coll. Y. Horie, No. 2918, NHL

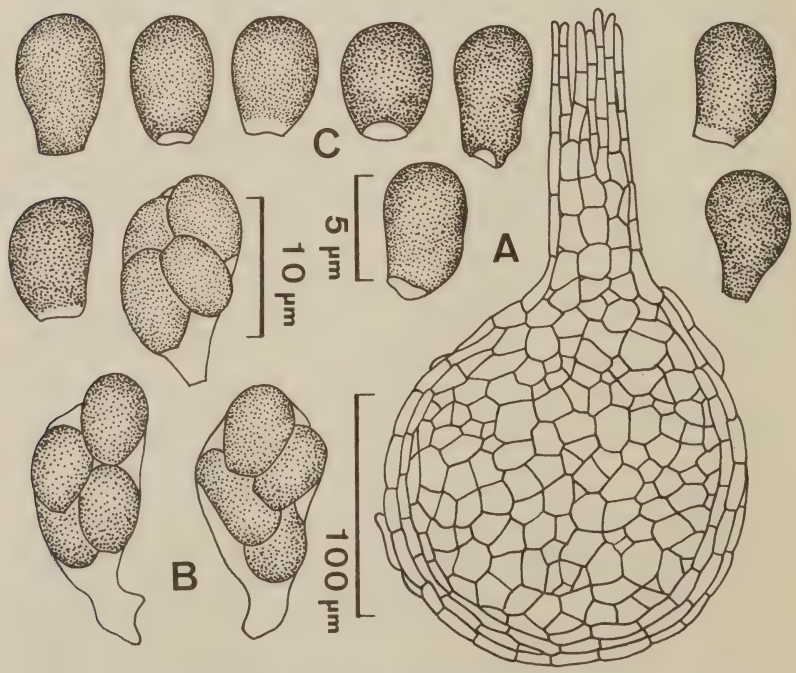


Fig. 1. *Arxiomyces campanulatus*, NHL-2918. A. Perithecium. B. Asci. C. Ascospores.

(Holotype). Isotypes: IMI 281910, IFM 4612.

Arxiomyces was published by Cannon & Hawksworth (1983a) as a replacement name for *Phaeostoma* von Arx & E. Müller, non Spach, the conservation of the later homonym having been rejected by the Special Committee for Fungi (Hawksworth & Sherwood, 1981; Petersen, *in litt.*). The type of the genus is *A. vitis* (Fuckel) P. Cannon & D. Hawksw., and the three other species previously assigned to *Phaeostoma* have been disposed elsewhere.

Arxiomyces has ovoid ascospores each having a conspicuous truncate base (probably acting as a very large germ pore) and a hyaline gelatinous appendage (often not visible in dried material) attached to the base. *Arxiomyces* is probably not closely related to *Melanospora*, and may well belong to the Lasiosphaeriaceae rather than the Ceratostomataceae (Hawksworth, *pers. comm.*), but its affinities remain unclear.

A. campanulatus is distinguished from *A. vitis* by its shorter neck, and larger ascospores ((5-)6-7 x 4-5 µm in *A. campanulatus* but 5-6 x 3-4 µm in *A. vitis*).

Persiciospora japonica Horie, Udagawa & P. Cannon, sp. nov. (Figs. 2, 6)

Perithecia superficialia, dispersa, dilute flavo-brunnea, globosa vel subglobosa, 240-440 µm diam, glabra vel sparsim pilosa; pili hyalini, recti, graciles, non-ramosi, leves, basi 3-5.5 µm diam; collum brevissimum vel nullum, usque 20 µm longum, 65-80(-120) µm diam; setae ostiolorum rectae vel parum curvae, hyalinae vel parum flavae, leves et plus minusve incrassatae, remote septatae vel non-septatae, 70-160 µm longae, basi 3-3.5 µm diam, apice 1.5-2 µm diam et obtusae. Peridium tenue, flavum vel modice flavo-brunneum, membranaceum, semitranslucens, 'textura angularis' vel 'textura globulosa'; stratum exterius ex celluis dilute flavis, 8-24 x 7-20 µm composito; stratum inferius ex cellulis hyalinis. Asci octospori, late clavati, 52-56 x 18-20 µm, superne rotundati, sine annulo incrassati, brevistipitati, evanescentes, in fasciculo irregulari dispositi, cum cellulis hyalinis, inflatis, 12-18 µm diam intermixti, sed paraphyses indistinctae. Ascosporae irregulariter biseriatae, primo hyalinae, deinde valde olivaceo-brunneae vel atrobrunneae, in massa fere nigrae, anguste ellipsoideae vel fusiformi-ellipsoideae, (16-)18-21(-23) x (8-)9-10 µm, utrinque subapiculatae, reticulate visae sub 'LM' sed punctatae vel punctato-reticulatae sub 'SEM'; foveae numerosae, isodiametrae vel plus

minusve irregulares, 0.5–0.8 µm diam; pori germinales ca. 1 µm diam in utroque apice instructo.

Mycelium ex hyphis hyalinis vel dilute flavis, ramosis, saepe anastomosantibus, septatis, levibus, incras-

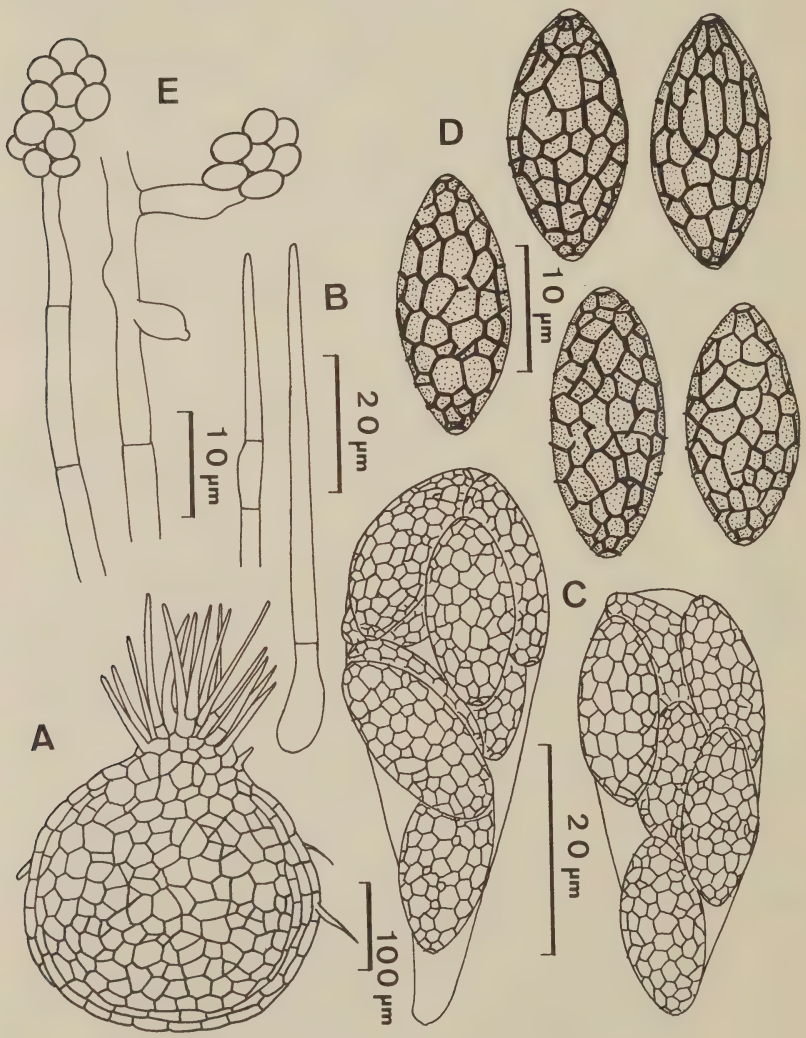


Fig. 2. *Persiciospora japonica*, NHL-2809.
A. Perithecium. B. Ostiolar setae. C. Asci.
D. Ascospores. E. Conidiogenous cells and conidia.

satis, 2-10 µm diam composito. Conidiophora plerumque nulla. Cellulae conidiogenae (monophialides) statim ex hyphis aeriis oriundis, raro in brevistipitibus, hyalinae, lageniformes, 6-10(-13) x 2.5-4 µm, cum cupula apicali. Conidia hyalina, unicellularia, obovoidea, 2.5-3.5(-4) x 2-3 µm, levia, in capitula globosa ad apices phialidum aggregatis. Chlamydosporae terminales vel intercalares, hyalinae, plus minusve globosae, 6-8 µm diam, leves et incrassatae.

Coloniae in agaro 'oatmeal' effusae, tenues, floccosae, albidae vel brunneo-aurantiacae; perithecia dispersa sed conidia limitata; reversum incoloratum vel griseo-aurantiacum.

Holotypus ----- isolatus e solo sylvatici, Ryozu-shi, Niigata, in Japonia, 20.ix.1975, legit. K. Furuya, No. 2809. In Herbario NHL. Isotypi: IMI 281909, IFM 4613.

Etymology: Latin, *japonica* = of Japan, referring to its wide distribution in this country.

Perithecia superficial, scattered, light yellowish brown, globose to subglobose, 240-440 µm diam, glabrous or sparsely clothed with hyaline, straight, slender, unbranched, smooth-walled, hyphal-like hairs measuring 3-5.5 µm wide at base; neck very short or absent, less than 20 µm in length, 65-80(-120) µm diam, terminated by straight to slightly curved ostiolar setae which are hyaline to very slightly yellow, smooth and rather thick-walled, remotely septate or aseptate, 70-160 x 3-3.5 µm at base, 1.5-2 µm at tip, apex obtuse; peridium thin, yellow to light yellowish brown, membranaceous, semitransparent, composed of *textura angularis* or *textura globulosa*; with an outer layer consisting of pale yellowish cells measuring 8-24 x 7-20 µm and an inner layer of hyaline cells. Asci 8-spored, broadly clavate, 52-56 x 18-20 µm, rounded above, without apical structure, short-stipitate, evanescent, borne in an irregular fascicle, intermixed with hyaline, swollen, 12-18 µm diam cells but with no definite paraphyses. Ascospores irregularly biseriately arranged, at first hyaline, becoming dark olivaceous brown to dark brown, nearly black in mass, narrowly ellipsoidal to fusiform-ellipsoidal, (16-) 18-21(-23) x (8-)9-10 µm, subapiculate at both ends, surface appearing reticulate in LM, the reticulum well-developed and fairly coarse, but punctate to punctate-reticulate in SEM, with many small isodiametric to somewhat irregular pits 0.5-0.8 µm diam, with terminal germ pores measuring ca. 1 µm diam.

Mycelium composed of hyaline to pale yellow, branched, often anastomosed, septate, smooth and thick-walled hyphae

measuring 2-10 µm diam. Conidiophores often lacking or not distinctly differentiated from the hyphae. Conidiogenous cells monophialidic, directly scattered on the aerial hyphae as side branches or on short stalks in a few groups, hyaline, lageniform, 6-10(-13) x 2.5-4 µm, with a small collarette. Conidia hyaline, one-celled, obovoid, 2.5-3.5 (-4) x 2-3 µm, smooth-walled, becoming aggregated into small globose heads at the apices of the phialides. Chlamydospores terminal or intercalary, hyaline, more or less globose, 6-8 µm diam, smooth and thick-walled.

Colonies on oatmeal agar growing rapidly, attaining a diameter of 62-75 mm within 14 days at 25 C, thin, consisting of submerged vegetative mycelium and floccose aerial hyphae, white to brownish orange (Methuen, 5C5); perithecia scattered amongst the aerial hyphae as black patches; conidia limited in number, not influencing the colony appearance; reverse uncoloured to greyish orange (Methuen, 5B4).

Colonies on potato-carrot agar growing rather slowly, conspicuously floccose.

At 37 C, growth is nil.

Isolation: forest soil, Ryozu-shi, Sado-gun, Niigata-pref., Japan, 20.ix.1975, coll. K. Furuya, No. 2809, NHL (Holotype). Isotypes: IMI 281909, IFM 4613.

Other isolations: grassland soil, Sugadaira, Sanada-machi, Chiisagata-gun, Nagano-pref., Japan, 20.vii.1978, coll. S. Udagawa, No. 2937, NHL; forest soil, Chichijima, Ogasawara-mura, Tokyo, Japan, 9.xii.1977, coll. Y. Horie, IFM 4613, 4616.

Persiciospora P. Cannon & D. Hawksw. (1982) is distinguished from *Melanospora* Corda essentially by the structure of the ascospores, which are delicately pitted rather than smooth-walled, and have very small, inconspicuous terminal germ pores, unlike the easily visible ones in *Melanospora*. Two species were originally placed in the genus, *P. moreaui* P. Cannon & D. Hawksw. and *P. masonii* (Kirschst.) P. Cannon & D. Hawksw.

P. japonica is evidently closely related to *P. moreaui* but differs in the much shorter neck of its perithecium, and in its slightly smaller ascospores which are more delicately and regularly punctate. *P. japonica* is associated with a *Phialophora* anamorph which is not known, in the other species.

Sphaerodes micropertusa Horie, Udagawa & P. Cannon, sp. nov. (Figs. 3, 7)

Perithecia superficialia, dispersa vel in catervis parvis aggregata, flavo-brunnea, pyriformia, basi globosa, ca. 180-220 µm diam, glabra vel parum pilosa; collum brevi-cylindricum, plus minusve contractum, 65-100 µm longum, basi 50-70 µm latum, apice 40-50 µm latum, glabrum, ad extremum ostiolatum; setae ostioli hyalinae vel stramineae, septatae, leves, non-ramosae, usque 20-35 µm longae, basi 3-5 µm latae, apice rotundae. Peridium dilute flavo-brunneum, incrassatius, membranaceum, semitranslucens, 'textura globulosa' vel 'textura angularis', ex cellulis angularibus, 10-25 µm diam composito; collum 'textura globulosa' vel 'textura epidermoidea', ex cellulis 8-12 x 4-6 µm diam composito. Asci octospori, late clavati vel ovoidei, 44-60 x 18-25 µm, superne late rotundi, sine annulo incrassato, brevistipitati, evanescentes; paraphyses nullae. Ascosporae irregulariter biseriatae, primum hyalinae et guttulatae, deinde valde olivaceo-brunneae vel atrobrunneae, in massa fere nigrae, fusiformi-limoniformes vel fere rhombeae, plus minusve complanatae e latere visis, 18-22(-28) x 9.5-11(-13) x 8-9 µm, aliquot cristis praeditae, parte convexa foveolatae; pori germinales manifeste in utroque apice instructi, 1-1.5 µm diam.

Mycelium ex hyphis hyalinis vel stramineis, ramosis, septatis, vulgo tenuibus, 2-6 µm diam composito. Conidiophora nulla. Cellulae conidiogenae (monophialides) plerumque ex hyphis aeriis oriundis, singulares vel in catervis parvis aggregatae, cylindraceae vel lageniformes, 4-8 x 2.5-4 µm. Conidia hyalina, unicellularia, tenuia, obovoidea vel pyriformia vel ellipsoidea, 3-5 x 2-3.5 µm, levia, in capitula globosa ad apices phialidum aggregatis.

Coloniae in agaro 'potato-carrot' lente crescentes, planae, tenues, floccosae, brunneo-flavae; perithecia abunde producentia sed conidia limitata; reversum incoloratum vel flavo-brunneum.

Holotypus ----- isolatus e solo sativo, Ohwadashinden, Yachiyo-shi, Chiba, in Japonia, 28.ix.1975, legit. Y. Horie, No. 2769. In Herbario NHL. Isotypi: IMI 281908, IFM 4614.

Etymology: Latin, *micro* = small and *pertusa* = perforated, referring to the ascospore ornamentation.

Perithecia superficial, scattered or aggregated in small groups, yellowish brown, pyriform, base globose, 180-220 µm diam, glabrous or very sparsely hairy; neck short cylindric, slightly tapering, 65-100 x 50-70 µm at base, 40-50 µm at tip, glabrous, terminated by poorly developed straight ostiolar setae which are hyaline to straw-coloured, septate, smooth-walled, unbranched, up to

20-35 µm long, 3-5 µm wide at base and with a rounded tip. Perithecial peridium pale yellowish brown, rather thick, membranaceous, semitransparent, composed of *textura globulosa* to *textura angularis*, consisting of large angular cells measuring 10-25 µm diam. Neck consisting of somewhat

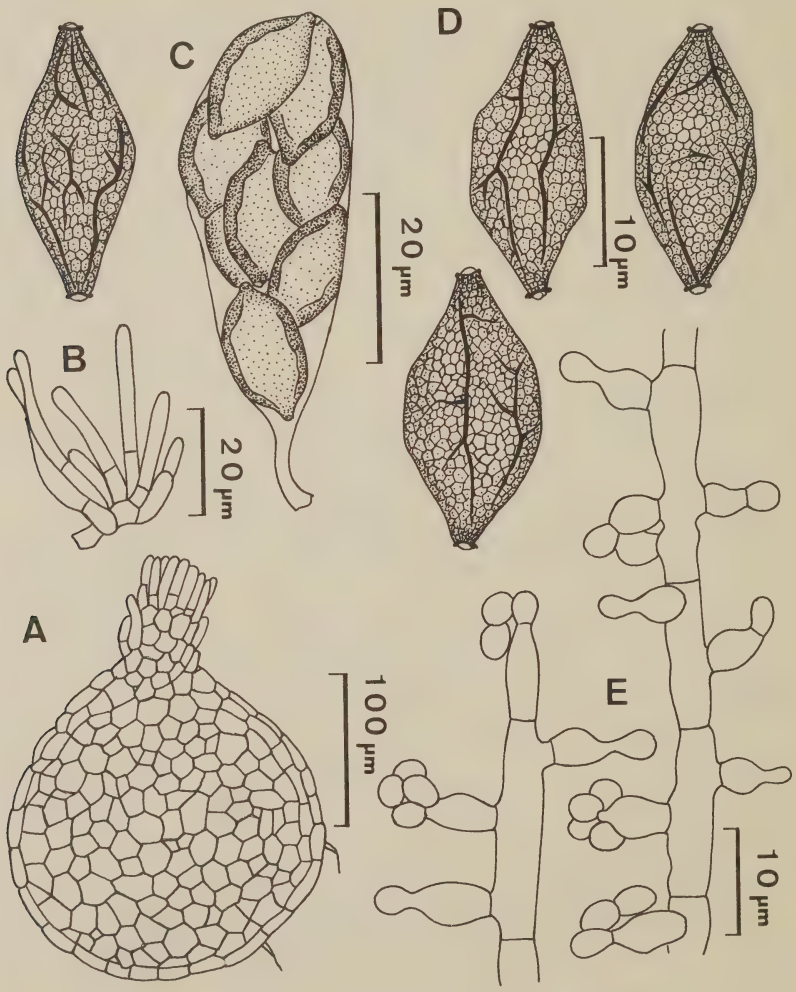


Fig. 3. *Sphaerodes micropertusa*, NHL-2769.
A. Perithecium. B. Ostiolar setae. C. Ascus.
D. Ascospores. E. Conidiogenous cells and conidia.

elongated and irregularly oriented *textura globulosa* to *textura epidermoidea* with cells 8–12 x 4–6 µm. Asci 8-spored, broadly clavate to ovoid, 44–60 x 18–25 µm, broadly rounded above, without apical structure, short-stipitate, evanescent; paraphyses lacking. Ascospores irregularly biseriately arranged, at first hyaline and guttulate, becoming dark olivaceous brown to dark brown, nearly black in mass, fusiform-limoniform to nearly rhombic in outline, slightly flattened in transverse section, 18–22(–28) x 9.5–11(–13) x 8–9 µm, ornamented with inconspicuous ridges forming a very coarse reticulum, surfaces delicately pitted, with prominent terminal, apiculate germ pores measuring 1–1.5 µm diam.

Mycelium composed of hyaline to straw-coloured, branched, septate, mostly smooth-walled, 2–6 µm diam hyphae. Conidiophores lacking. Conidiogenous cells monophialidic, usually scattered on the aerial hyphae as side branches, solitary or in small clusters, cylindric to flask-shaped, 4–8 x 2.5–4 µm. Conidia hyaline, one-celled, thin-walled, obovoid or pyriform to ellipsoidal, 3–5 x 2–3.5 µm, smooth-walled, becoming aggregated into 10–12 µm diam, globose heads at the apices of the phialides.

Colonies on potato-carrot agar growing restrictedly, attaining a diameter of 9–12 mm within 14 days at 25 C, flat, thin, consisting of submerged vegetative mycelium and white floccose aerial hyphae, brownish yellow (Methuen, 5C8), developing abundant perithecia in black patches on the agar surface; conidia limited in number, not influencing the colony appearance; reverse hyaline to yellowish brown (Methuen, 5E4). Colonies on malt agar growing rather rapidly, thin, floccose.

At 37 C, growth is nil.

Isolation: cultivated soil, Ohwadashinden, Yachiyo-shi, Chiba-pref., Japan, 28.ix.1975, coll. Y. Horie, No. 2769, NHL (Holotype). Isotypes: IMI 281908, IFM 4614.

Additional isolation: cultivated soil, Sugadaira, Sanada-machi, Chiisagata-gun, Nagano-pref., Japan, 4.x.1982, coll. Y. Horie, IFM 4614.

Sphaerodes Clem., erected in 1909 with a single species, *S. episphaeria* (Phill. & Plowr.) Clem., is also similar in appearance to *Melanospora* but differs considerably in its ascospore characters. *Sphaerodes* has very dark brown ascospores which are usually rhombic or nearly so in vertical section and often flattened in transverse section, with very coarse reticulate ornamentation. The walls of the two terminal germ pores are prominent and usually umbonate, and are themselves often reticulately ornamented.

Some smooth-spored species which apparently have the characteristic germ pores of *Sphaerodes* may also be included here.

S. micropertusa illustrates the difficulty of classifying the Ceratostomataceae relying too heavily on ascospore ornamentation, because though the spore shape and germ pores are typical of *Sphaerodes*, and it has the coarse reticulum found in that genus, it also has a secondary, very delicate reticulum which might suggest an affinity with *Persiciospora*. This second type of ornamentation is only clearly visible at magnifications of x1000 and above. The shape of the ascospores and form of the germ pores, however, make placement in *Sphaerodes* appropriate.

S. micropertusa is easily distinguished from other species of *Sphaerodes*, differing from *S. fimicola* (Hansen) P. Cannon & D. Hawksw., the only other ostiolate member of the genus, by the much longer neck of its perithecium.

Syspastospora boninensis Horie, Udagawa & P. Cannon, sp. nov. (Figs. 4, 8)

Cleistothecia superficialia vel immersa, dispersa vel in catervis parvis aggregata, nigra per massam ascosporarum, globosa vel subglobosa, 40–120 µm diam, glabra vel parum pilosa; peridium dilute flavo-brunneum, tenue, ca. 6–15 µm crassum, membranaceum, semitranslucens, 'textura intricata' vel 'textura angularis', ex cellulis hyalinis vel stramineis, tenuibus, 4–10 µm diam composito. Asci in fasciculo ad centrum dispositi, vulgo octospori, ovoidei vel late clavati, 14–22 x 10–12(–15) µm, superne late rotundi, sine annulo incrassati, brevistipitati, evanescentes; paraphyses nullae. Ascosporae irregulariter bi- vel triseriatae, unicellulares, primum hyalinae et guttulatae, deinde modice brunneae vel olivaceo-brunneae, cylindraceae vel doliiformes, 6–9 x 4–4.5 µm, leves, utrinque truncatae et labiatae; pori germinales 1.5–2 µm diam in utroque apice instructo.

Mycelium ex hyphis hyalinis vel dilute flavo-brunneis, ramosis, septatis, levibus, 2–6 µm diam composito. Chlamydosporae 6–10 µm diam, globosae vel ovoideae, hyalinae, leves, crassae, terminales vel intercalares, solitariae vel catenulatae.

Coloniae in agaro 'potato-carrot' effusae, tenues, floccosae, albidae vel pallide flavae; cleistothecia abunde producentia in areas centrales, griseo-brunnea; reversum fere incoloratum.

Holotypus ----- isolatus e solo sativi, Hahajima,

Ogasawara-mura, Tokyo, in Japonia, 6.xii.1977, legit. Y. Horie, No. 2845. In Herbario NHL. Isotypi: IMI 281907, IFM 4615.

Etymology: Latin, *boninensis* = the Bonin Islands (Ogasawara), referring to the type locality.

Cleistothecia superficial or immersed in the substratum, scattered or aggregated in small groups, black due to spore mass, globose to subglobose, 40-120 µm diam, glabrous

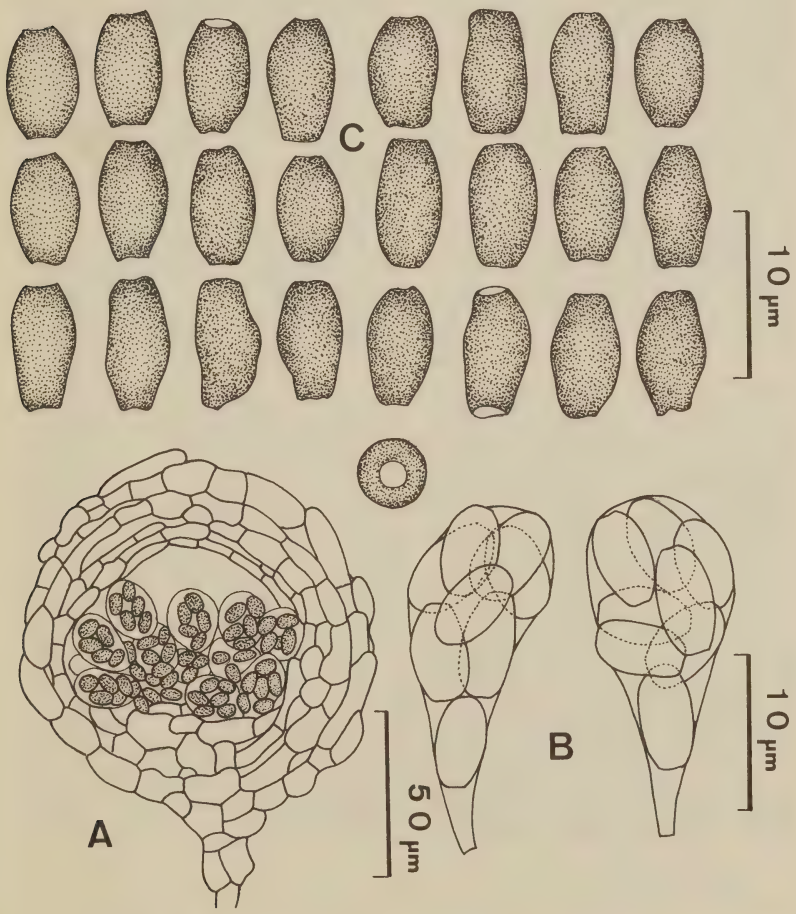
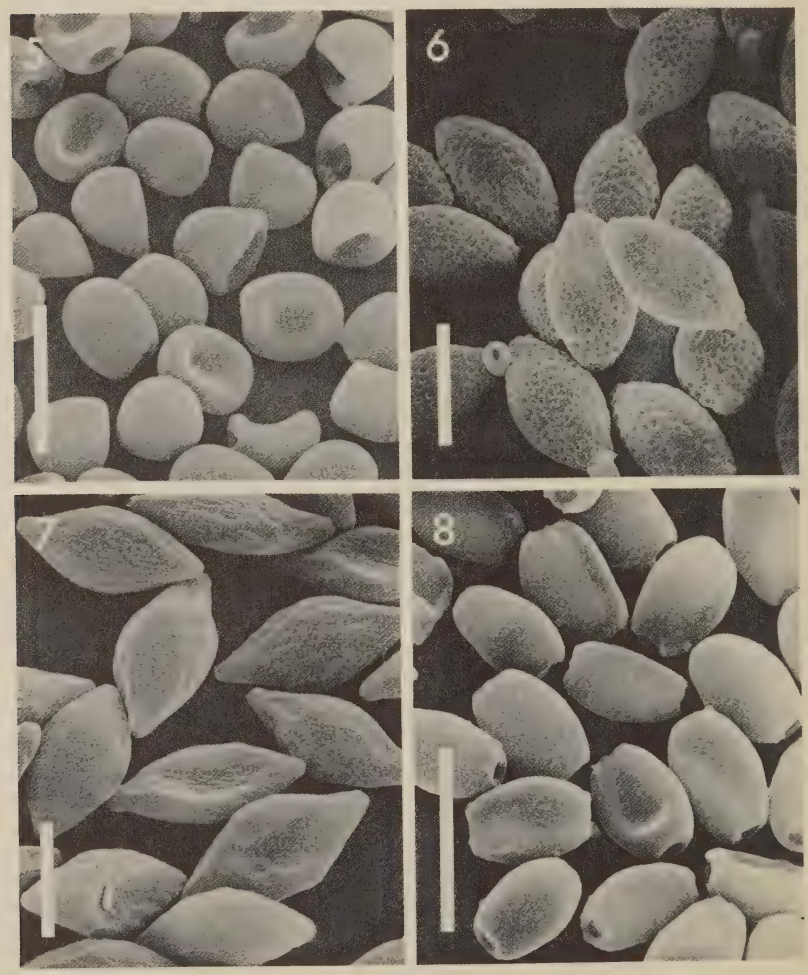


Fig. 4. *Syspastospora boninensis*, NHL-2845. A. Cleistothecium. B. Asci. C. Ascospores.

or very sparsely hairy; peridium pale yellowish brown, thin, ca. 6–15 µm thick, membranaceous, semitransparent, composed of *textura intricata* to *textura angularis*, consisting of hyaline to straw-coloured, thin-walled cells



Scanning electron micrographs of ascospores of *Arxiomyces campanulatus* (Fig. 5), *Persciospora japonica* (Fig. 6), *Sphaerodes micropertusa* (Fig. 7) and *Syspastospora boninensis* (Fig. 8). All scales = 10 µm.

measuring 4–10 µm diam. Asci arranged in a fascicle in the central part of the cleistothecium, usually 8-spored, ovoid to broadly clavate, 14–22 x 10–12(–15) µm, broadly rounded above, without apical structure, short-stipitate, evanescent; paraphyses lacking. Ascospores irregularly bi- or triseriately arranged, one-celled, at first hyaline and guttulate, becoming mid-brown to olive-brown, cylindric to doliiform, 6–9 x 4–4.5 µm, smooth-walled, ends truncate, with two large slightly sunken apical germ pores 1.5–2 µm diam, with puckered rims.

Mycelium composed of hyaline to pale yellowish brown, branched, septate, smooth-walled hyphae measuring 2–6 µm diam. Cleistothecial initials appearing as swollen knots of branches on hypha, becoming contorted and interlaced each other. Chlamydospores present, 6–10 µm diam, globose to ovoid, hyaline, thick-walled, terminal or intercalary, solitary or a few in connectives, tending to aggregate in small clusters.

Colonies on potato-carrot agar spreading broadly, attaining a diameter of 78–82 mm within 14 days at 25 C, consisting of a thin basal felt with abundant aerial growth, appearing floccose, white or light yellow (Methuen, 4A4), developing abundant cleistothecia at the central areas coloured in greyish brown (Methuen, 5F3) shades; reverse almost uncoloured.

Colonies on Weitzman and Silva-Hutner's medium (Weitzman and Silva-Hutner, 1967) spreading, floccose, with little production of cleistothecia.

At 37 C, growth-rate is similar to that at 25 C, but cleistothecia are not usually formed.

Isolation: cultivated soil after burning, Hahajima, Ogasawara-mura, Tokoyo, Japan, 6.xii.1977, collected by Y. Horie, no. 2845, NHL (Holotype). Isotypes: IMI 281907, IFM 4615.

Syspastospora, erected by Cannon & Hawksworth (1982) to accommodate *S. parasitica* (Tul.) P. Cannon & D. Hawksw., differs from *Melanospora* by its cylindrical to doliiform ascospores with very large terminal crateriform germ pores, which have slightly puckered rims. In addition, the neck of the perithecium in *Syspastospora* is made up of parallel hyphae while in *Melanospora* it is cellular in construction.

S. boninensis is immediately distinguished from *S. parasitica* by its non-ostiolate ascomata, and much wider ascospores, which are 4–4.5 µm wide in *S. boninensis* but only 2–2.5 µm wide in *S. parasitica*.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Dr. Kouhei Furuya, Sankyo Co. Ltd.,for supplying the culture of *Persiciospora japonica*, and Dr. David L. Hawksworth, Director of the Commonwealth Mycological Institute, for providing useful suggestions. The authors also thank Prof. R. T. Hanlin of the University of Georgia and Prof. G. Morgan-Jones of the Auburn University for reviewing this paper.

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MYCOTAXON

Vol. XXV, No. 1, pp. 247-250 January-March 1986

NOTES ON HYPHOMYCETES. LI. *KAMESHWAROMYCES*, A NEW FOLIICOLOUS, SOOTY MOLD-LIKE GENUS FROM MADHYA PRADESH, INDIA

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ABSTRACT

Kameshwaromyces globosus Kamal, Verma and Morgan-Jones, a new genus and species, which occurs superficially on the abaxial surface of leaves of *Elephantopus scaber* L., in Madhya Pradesh, India, is described and illustrated.

INTRODUCTION

During the course of a study of foliicolous, dematiaceous Hyphomycetes occurring in the Panchmari Hills of Madhya Pradesh, India, one of us (R.K.V.) has collected a fungus of unique morphology growing superficially in the manner of a sooty mold on the abaxial surface of leaves of *Elephantopus scaber*. Examination of its habit by means of the collodion technique for the study of foliicolous sooty molds (Hughes, 1976) indicates that it produces an extensive network of anastomosing, repent hyphae closely appressed to the leaf surface. Its hyphae do not penetrate the epidermis. It perhaps qualifies to be referred to as a sooty mold in the broad vernacular sense although it does not produce an intense, truly sooty appearance such as that characteristic of fungi associated with honey dew deposited by various insects. It is presumed that it obtains nutrients to sustain growth from leachates in the phylloplane.

We believe this fungus to be undescribed and to be so distinct as to warrant accommodation in a new genus.

TAXONOMIC PART

Kameshwaromyces gen. nov.

Deuteromycotina, Hyphomycetes, Dematiaceae.

Alabama Agricultural Experiment Station Journal Series No. 6-85899.

Coloniae effusae, atrae. Mycelium superficiale, ex hyphis pallide brunneis, laevibus, septatis, cylindricis, repentibus, ramosis, anastomosantibus compositum. Conidiophora micronemata. Cellulae conidiogenae monoblasticae, in hyphis vegetativis incorporatae, intercalares vel terminales, cylindricae. Conidia solitaria, sicca, ex apice lateribusque hypharum oriunda, globosa, parietibus crassis, brunnea vel atrobrunnea, muriformia, multicellularia, laevia vel aspera.

Species typica: *Kameshwaromyces globosus* Kamal, Verma and Morgan-Jones.

Colonies effuse, black. Mycelium superficial, composed of pale brown, smooth, septate, cylindrical, repent, branched, anastomosing hyphae. Conidiophores micronematous. Conidiogenous cells monoblastic, incorporated in the vegetative hyphae, intercalary or terminal, cylindrical. Conidia solitary, smooth, arising terminally and laterally on the hyphae, globose, thick-walled, brown to dark brown, muriform, multicellular, smooth or roughened.

[Etymology: the new genus is named in honor of Professor Kameshwar S. Bhargava, the teacher of one of us (Kamal), et Gr. *myces* = fungus]

Kameshwaromyces globosus sp. nov. (Figure 1).

Coloniae semper hypophyllae, late effusae, diffusae, primo cinnamomea, demum ubi densiores atrae. Mycelium superficiale, ex hyphis pallide brunneis, laevibus, septatis, cylindricis, repentibus, ramosis, anastomosantibus, 2-3µm crassis comositum. Conidiophora micronemata. Cellulae conidiogenae monoblasticae, in hyphis vegetativis incorporatae, intercalares, cylindricae. Conidia solitaria, acrogena, sicca, ex apice lateribusque hypharum oriunda, globosa, parietibus crassis, brunnea vel atrobrunnea, muriformia, multicellularia, laevia vel aspera, interdum fimbriata, 32-50µm diam.

In foliis vivis Elephantopi scaber, Panchmari Hills, Madhya Pradesh, India, August 1984, R.K. Verma, AUA, holotypus.

Colonies always hypophyllous, spreading relatively widely, diffuse but tending to be better developed in the vicinity of the main leaf veins, at frist pale cinnamon-brown in color, assuming a black appearance with the production of conidial clusters. Mycelium superficial, composed of pale brown, smooth, septate, cylindrical, repent, branched, anastomosing, 2-3µm wide hyphae. Hyphae forming a loose network or a somewhat dense subiculum in places, with short, interlocking lateral branches. Laterally produced hyphal branches frequently becoming acutely bent following contact with other hyphae and ensuing terminal growth. Conidiophores micronematous. Conidiogenous cells monoblastic, incorporated in the vegetative hyphae, terminal or, more frequently, intercalary, cylindrical. Conidia solitary, acrogenous, dry, arising terminally but mostly laterally from intercalary hyphal cells, where lateral frequently on a very short hyphal extension, globose, thick-walled, brown to dark brown, muriform, multicellular, with individual cells disctinctly angular in configuration, smooth or irregularly roughened, often with a portion of the wall of the conidiogenous cell remaining attached as a basal frill following secession, 32-50µm in diameter.

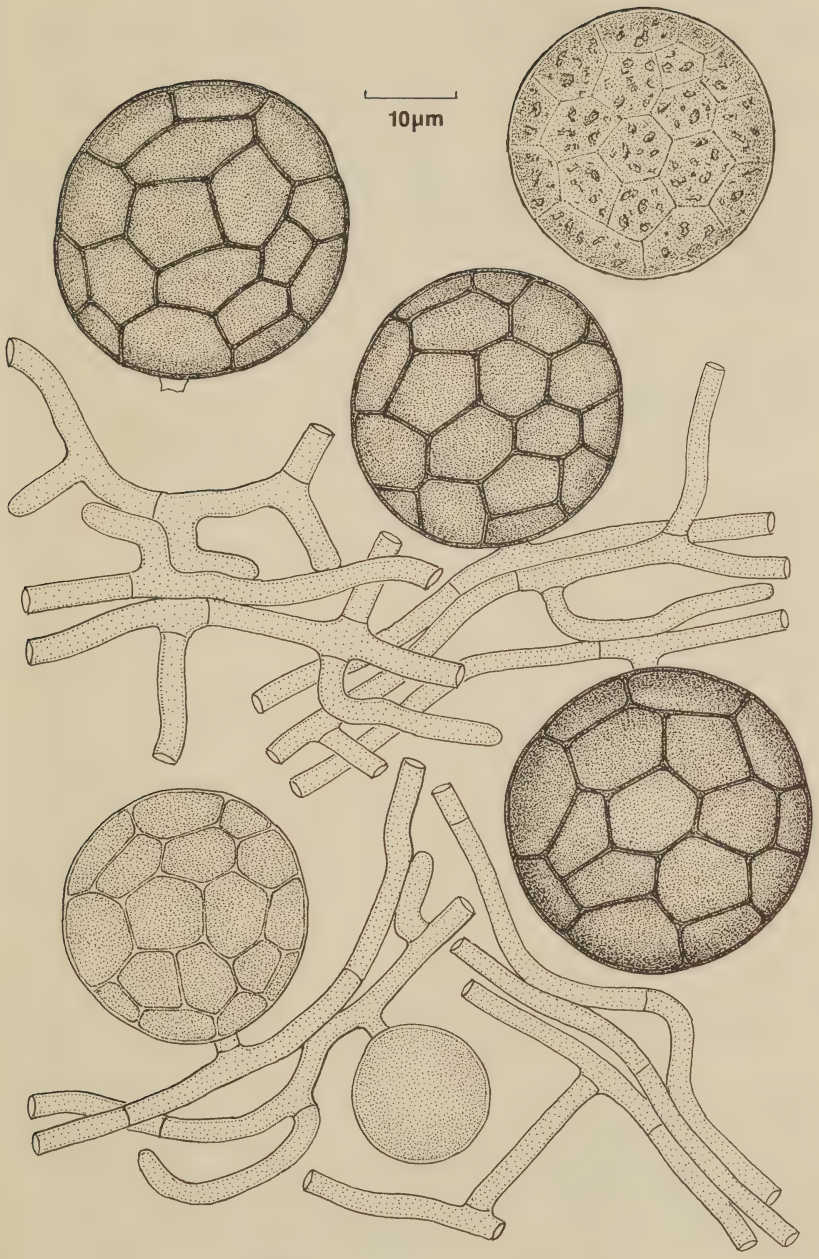

FIGURE 1. *Kameshwaromyces globosus.*

On living leaves of *Elephantopus scaber* L.; India.

Collection examined: on *E. scaber*, Panchmari Hills, Madhya Pradesh, India, August 1984, R.K. Verma, AUA, IMI 290576, GPU (KRN 5), type.

When viewed under a stereoscope the conidia of *Kameshwaromyces globosus* appear as shiny, black balls. They occur predominantly in dense clusters. The conidia are chlamydosporic in character and appearance and are not true *conidia vera sensu* Vuillemin (1910). Among known dematiaceous Hyphomycetes they most closely resemble in morphology those of *Dictyopolyschema* M.B. Ellis, but that genus is very different in having well-differentiated, discrete, tretic conidiogenous cells.

ACKNOWLEDGMENT

We thank Dr. J. Leland Crane, State Natural History Survey Division, Illinois Department of Energy and Natural Resources, for kindly reviewing the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 251-254 January-March 1986

ARCTOPARMELIA, A NEW GENUS IN THE PARMELIACEAE (ASCOMYCOTINA)

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Abstract.--The Xanthoparmelia centrifuga group is recognized as a distinct genus, Arctoparmelia, on the basis of lower surface characters, medullary chemistry, macromolecular iodine reactions and geography. The following new combinations are made: Arctoparmelia aleuritica (Nyl.) Hale, A. centrifuga (L.) Hale, A. incurva (Pers.) Hale, A. separata (Th. Fr.) Hale and A. subcentrifuga (Oxner) Hale.

The genus Xanthoparmelia (Vain.) Hale was established in 1974 (Hale, 1974) to accomodate the obligately saxicolous, epicorticate, usnic-acid containing species formerly classified in Parmelia. Several anomalous groups have recently been identified within the genus as I originally circumscribed it. One, a small group of umbilicate species, the Parmelia hottentotta group, is now recognized as a new genus, Xanthomaculina (Hale, 1985a).

A second anomalous group includes the well-known X. centrifuga and related species. They differ from other species in the genus in always containing alectoronic acid, in having a curious velvety, ivory-white to purplish lower surface and in geographic restriction to arctic-boreal regions. This combination of characters is sufficiently distinct to remove these species from Xanthoparmelia and place them in a new genus, Arctoparmelia. The removal of these groups leaves Xanthoparmelia as a highly homogeneous assemblage of about 210 species predominantly occurring on rocks in dry temperate regions.

Arctoparmelia Hale, gen. nov.

Thallus adnatus vel laxe adnatus, viridi-flavicans vel raro cinereo-albus, lobis sublinearibus, cortice superiori epicorticato, cortice inferiori minute papillato, rhizinis sparsis vel fere nullis. Apothecia adnata, imperforata, sporis 8:nis, simplicibus, conidiis bifusiformibus.

Type species: Lichen centrifugus L.

Arctoparmelia has several interesting morphological features. The cortex is epicorticate, although the surface is often obscured by amorphous pruina-like accretions. Externally the lower cortex appears to be dull and velvety, ivory white to pale brown in A. aleuritica and A. centrifuga, but darker brown in A. incurva and purplish black in A. separata and A. subcentrifuga. Under the scanning electron microscope the velvety nature can be correlated with regular knobby projections of the outermost cortical cells. Rhizines are often sparsely developed.

Arctoparmelia exhibits significant chemical differences from Xanthoparmelia. The medullary chemistry is uniform in all the species in the new genus: Alectoronic acid usually accompanied by α-collatolic acid. Except for one rare Andean species with normal Xanthoparmelia morphology, X. alectoronica Hale (Hale, 1985b), alectoronic acid does not occur in Xanthoparmelia. In addition, the upper cortex of Arctoparmelia species contains considerable amounts of atranorin, easily detected on TLC plates, and usnic acid (except for A. aleuritica), whereas atranorin is absent or produced only in trace amounts in Xanthoparmelia. A more significant chemical difference between the two genera, however, is their macromolecular chemistry. While both contain lichenin, Arctoparmelia species give a negative reaction with I(CH) (chloral hydrate). Xanthoparmelia is I(CH) positive (Imshaug, in litt.).

There are five closely related species in Arctoparmelia, as follows:

Arctoparmelia aleuritica (Nyl.) Hale, comb. nov.
Parmelia aleuritica Nyl., Flora 58:103. 1875.
Parmelia centrifuga var. dealbata Th. Fr., Lichenogr. Scand. 1:129. 1871.

This is the only species lacking usnic acid in the cortex. It is restricted to Scandinavia where it is considered as an usnic acid-free mutant of A. centrifuga.

Arctoparmelia centrifuga (L.) Hale, comb. nov.
Lichen centrifugus L., Sp. Pl. 1142. 1753.
Parmelia centrifuga (L.) Ach., Meth. Lich. 206. 1803.
Xanthoparmelia centrifuga (L.) Hale, Phytol. 28:486. 1974.

This is one of the most abundant, conspicuous foliose lichens on rocks in the Arctic (see Thomson (1984) for detailed distribution in North America).

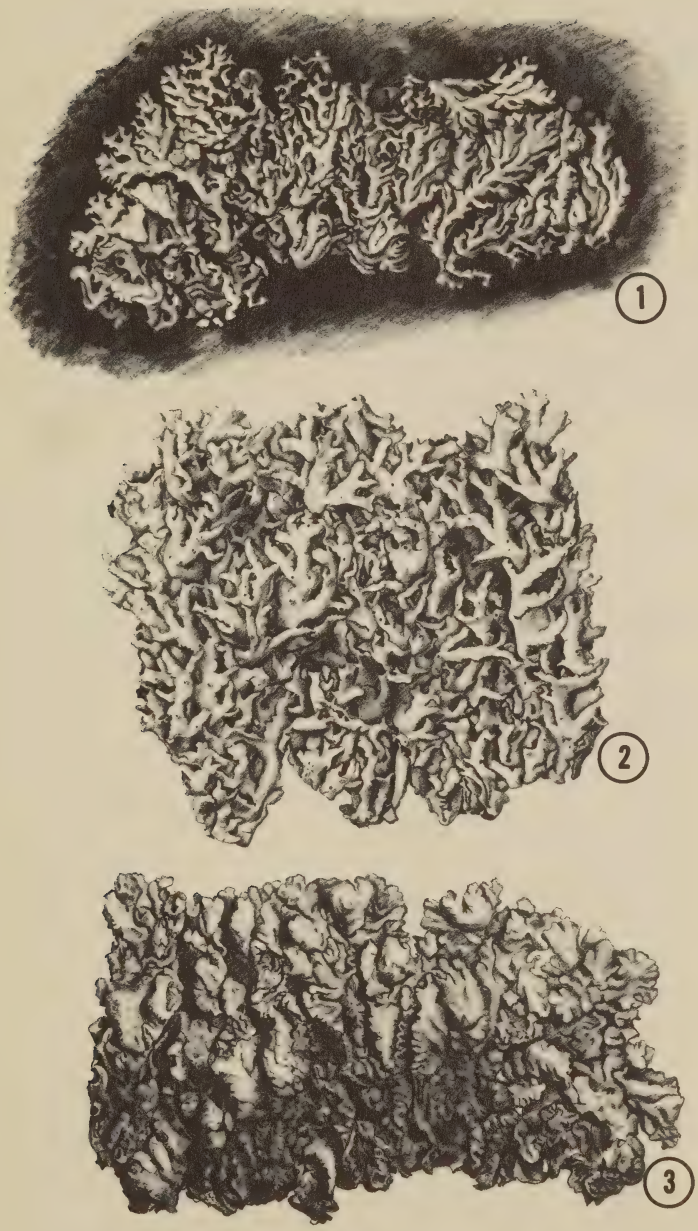
Arctoparmelia incurva (Pers.) Hale, comb. nov.
Lichen incurvus Pers., Usteri Ann. Bot. 3:24. 1794.
Lichen multifidus Dicks., Pl. Crypt. Brit. 3:16(7). 1793. Not. L. multifidus Scop., Fl. Carniol. 2:396. 1772 (=Collema).
Parmelia recurva Ach., Meth. Lich. 201. 1803.
Xanthoparmelia incurva (Pers.) Hale, Phytol. 28:488. 1974.

This is the only sorediate species in the genus (Fig. 1). It is circumpolar with A. centrifuga.

Arctoparmelia separata (Th. Fr.) Hale, comb. nov.
Parmelia separata Th. Fr., Jour. Linn. Soc. Lond. 17:353. 1880.
Parmelia centrifuga var. muscivaga Nyl., Bull. Soc. Linn. Norm., ser. 4, 1:201. 1887.
Parmelia birulae Elenkin, Ann. Mycol. 4:36. 1906.
Parmelia diffugiens Zahlbr., Bot. Mag. (Tokyo) 41:348. 1927.
Parmelia muscivaga (Nyl.) Gyel., Ann. Mus. Nat. Hung. 30:23. 1935.
Parmelia birulae var. grumosa Llano, Jour. Wash. Acad. Sci. 41:197. 1951.
Xanthoparmelia separata (Th. Fr.) Hale, Phytol. 28:489. 1974.

The lower surface is deep purplish black and the long lobes divaricately branched (Fig. 2), characters which separate the species from A. centrifuga. It occurs across arctic Canada into Alaska, in Japan and in Siberia west to Novaya Zemlya. There are no records from Europe.

Arctoparmelia subcentrifuga (Oxner) Hale, comb. nov.
Parmelia subcentrifuga Oxner, Jour. Bot. Acad. Sci. RSS Ukraine 1(3-4):39. 1940.
Parmelia groenlandica Lynge in Lynge & Scholander, Skrift. Svalb. Ishav. 41: 73. 1932. Not P. groenlandica (Oed.) Ach., Meth. Lich. 241. 1803. (=



Figs. 1-3. Species of Arctoparmelia. 1: A. incurva (X3). 2: A. separata (X1.5). 3: A. subcentrifuga (X2). Drawings by J. Schroeder.

Nephroma).

Xanthoparmelia subcentrifuga (Oxner) Hale, Phytol. 28:489. 1974.

This rare species occurs sporadically in Greenland, Baffin Island, along the north shore of Lake Superior in Canada, the Rocky Mountains, Alaska, SW Siberia and Nepal (records in US). The blackish lower surface is similar to that of A. separata but the upper surface is strongly and coarsely rugose-pustulate (Fig. 3).

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MYCOTAXON

Vol. XXV, No. 1, pp. 255-257 January-March 1986

HORMOTHECA FOR SPECIES OF COLEROA WITH HEMISPHERICAL ASCOMATA

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Coleroa chaetomium (Kunze:Fr.) Rabenh., the type species of the genus *Coleroa* Rabenh., possesses saccate asci and greenish, 1-septate ascospores within globose, setose ascomata which develop beneath the cuticle of living leaves of *Rubus* species. *Hormotheca robertiani* (Fr.) v. Höhn. (=*Hormotheca geranii* (Wallr.) Bonorden), the type species of the genus *Hormotheca* Bon. is characterized by oblong to saccate asci, greenish to yellowish, 1-septate ascospores but is distinguished from *C. chaetomium* by its hemispherical, non setose ascomata which develop beneath the cuticle of living leaves of *Geranium robertianum* L. Müller and von Arx (1962) synonymized *Hormotheca* under the older generic name *Coleroa* in the family Venturiaceae Müller & v. Arx ex Barr because of the similarities of the asci and ascospores and the common subcuticular habit on leaves. They considered the differences in ascoma morphology, globose ascomata in *C. chaetomium* and hemispherical ascomata in *H. robertiani*, to be unimportant at the generic level. This concept of *Coleroa*, sensu Müller and von Arx (1962), was adopted by Barr (1968) who accommodated *C. chaetomium* and similar species with globose ascomata in the subgenus *Coleroa* and *H. robertiani* and other species with hemispherical ascomata in the new subgenus *Hormotheca* (Bon.) Barr. Corlett (1977a, b; 1978) also followed the taxonomic concepts of Müller & von Arx and those of Barr. Luttrell (1973) however, maintained *Hormotheca* as distinct, including this genus in the family Munkiellaceae (Theiss. & Syd.) Luttrell, characterized by the presence of hemispherical, subcuticular ascomata. He retained *Coleroa* in the Venturiaceae. Von Arx and Müller (1975) considered *Hormotheca* to be a synonym of *Coleroa* in an enlarged Venturiaceae (as Stigmateaceae Theiss.) which also included the Munkiellaceae. Barr (1979, 1982), in her recent classification of the Loculoascomycetes, agreed with Luttrell (1973). She maintained *Coleroa* in the Venturiaceae and *Hormotheca* in the closely related Munkiellaceae. O. Eriksson (1981) recognized that the family Munkiellaceae is not separable from the Polystomellaceae Theiss. & Syd. Barr now accepts the family Polystomellaceae to include genera such as *Hormotheca*.

We now believe that the differences in ascoma morphology between *Hormotheca* and *Coleroa* warrant their retention as distinct genera in the Polystomellaceae and the Venturiaceae, respectively. We would restrict the genus *Coleroa* to *C. chaetomium* and similar species with globose ascomata. The species with hemispherical ascomata previously accepted in *Coleroa* by Müller and von Arx (1962), Barr (1968) and Corlett (1977a,b; 1978) are disposed in *Hormotheca* as follows with the requisite new combinations.

Hormotheca plantaginis (Ellis) comb. nov.
BASIONYM: *Asterina plantaginis* Ellis, Bull. Torrey Bot. Club 9:74. 1882.
Asterella plantaginis (Ellis) Sacc., Syll. Fung. 9:398. 1891 (as *Asterella plantaginis* Ellis).
Mycosphaerella plantaginis (Ellis) Theiss., Ann. Mycol.10:196. 1912.
Mycosphaerella theissenii Tomilin, Nov. Sist. niz. Rast. 8:152. 1971, syn.:*Mycosphaerella plantaginis* (Ellis) Theiss., non *Mycosphaerella plantaginis* (Sollm.) Vest.
Aphysa plantaginis(Ellis) Theiss., Ann. Mycol. 15:402. 1917.
Coleroa plantaginis (Ellis) Barr, Can. J. Bot. 46:833. 1968.

Hormotheca robertiani (Fr.) v. Höhn., Hedwigia 62:44. 1921.
Dothidea robertiani Fr., Syst. Mycol. 2:564. 1823.
Stigmatea robertiani (Fr.)Fr., Summa Veget. Scand. p. 421. 1849.
Ascospora robertiani (Fr.) Kuntze, Rev. Gen. Plant. 3(2):444. 1898.
Munkiella robertiani (Fr.) v. Höhn., Ann. Mycol.16:172. 1918.
Coleroa robertiani (Fr.) Müller, in Müller & v. Arx, Beitr. Krypt. Fl. Schweiz 11(2):416. 1962.
Cryptosphaeria nitida Grev., Fl. Edin. p.363. 1824.
Sphaeria geranii Wallr., Crypt. Germ. 2:771. 1833.
Hormotheca geranii (Wallr.) Bon., Abhandl. Naturf. Ges. Halle 8:149. 1864 (as *H. geranii* Wallr.).

Hormotheca rubicola (Ellis & Everh.) comb. nov.
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The authors thank Dr. J.C. Krug, Department of Botany, University of Toronto and Drs. R.A. Shoemaker and G.A. Neish, Biosystematics Research Institute, for reviewing the manuscript.

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MYCOTAXON

Vol. XXV, No. 1, pp. 259-269 January-March 1986

TAXONOMIC NOTES ON SOME POWDERY MILDEWS OF VARIOUS GENERA

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The present paper contains the following descriptions and combinations: Leveillula simonianii U. Braun spec. nov., Microsphaera itoana Y. Nomura, S. Tanda & U. Braun spec. nov., M. orixae U. Braun & S. Tanda spec. nov., M. paederiae S. Tanda, Y. Nomura & U. Braun spec. nov., M. wallrothii U. Braun & S. Tanda spec. nov., Sphaerotheca euphorbiae-hirtae U. Braun & R. B. Somani spec. nov., Uncinula matsunamiana Y. Nomura, S. Tanda & U. Braun spec. nov., U. viburni Y. Nomura, S. Tanda & U. Braun spec. nov., Oidium cinnamomi (Yen) U. Braun stat. nov., O. cinnamomi-japonici U. Braun spec. nov., O. schmiedeknechtii U. Braun spec. nov., O. stapeliae (Picbauer) U. Braun stat. nov., O. nephelii Hadiwidjaja ex U. Braun spec. nov., O. caesalpiniacearum Hosagoudar & U. Braun spec. nov., O. ipomoeae (Yen & Wang) U. Braun stat. nov., O. robustum U. Braun & E. Oehrens B. spec. nov., and O. araliacearum U. Braun & E. Oehrens B. spec. nov.

1. Leveillula simonianii U. Braun spec. nov.

Syn.: Leveillula taurica f. thevenotiae Jaczewski (1927, p.406), nom. nud. Leveillula thevenotiae (Jacz.) Golovin (1956, p.231), not valid, basionym a nom. nud., no Latin description added.

Etym.: Dr. S. Simonian, mycologist in Armenia.

Mycelium amphigenum. Conidiis primariis ± lanceolatis, conidiis subsequentibus ± cylindraceis - ellipsoideis, ca. 35-50 x 13-19 µm. Conidia verrucosae - squamulosae. Cleistothecia sparsa vel gregaria, 150-220 µm diam., cellulae peridii irregulariter angulatae, obscurae, ca. 8-15 µm diam., appendices mycelioideae, hyalinae, tenuitunicatae, verruculosae, 4-6 (-8) µm latae, diametro

cleistothecii 0.25-1 plo longiores, asci numerosae, ca. 20-25, 70-95 x 30-40 µm, ascosporae 2, 24-32 x 14.5-21 µm. Fig. 1.

Holotypus: hospes - Thevenotia scabra Boiss., Iran, Teheran, 1892, Bornmüller 4370 (FH).

The cleistothecia possess few to fairly numerous appendages in the lower half, they are aseptate or with few inconspicuous septa. This fungus differs from all species of Leveillula by the structure of the conidial surface. The conidia are very conspicuously verrucose (fig. 1). L. simonianii is known on Thevenotia scabra and persica from Iran and Turkmenia.

2. Microsphaera itoana Y. Nomura, S. Tanda & U. Braun spec. nov.

Etym.: S. Ito, Japanese mycologist.

Mycelium amphigenum. Cleistothecia sparsa, 90-115 µm diam., cellulae peridii irregulariter angulatae, ca. 9-17 x 6-14 µm, appendices 5-7, diametro cleistothecii 1-1.5 plo longiores, ca. 95-160 µm, hyalinae, non septatae, superne tenui-, inferne crassitunicatae, ad apicem dichotome ramosae (3-5 x), ramis ultimis recurvatis, asci 6-7, 50-55 x 33-40 µm, ascosporae 6, 16-18 x 6-12 µm. Fig. 2.

Holotypus: hospes - Atractylodes japonica Koidz., Japan, Mt. Mitake-san, Tokyo, Oct. 31, 1961, Y. Nomura (YNMH, herb. Nomura).

The appendages arise equatorially, they are rather stiff, the branchings are regular, somewhat loose. The asci are shortly stalked. The type host, a member of the Asteraceae, is very unusual for a species of the genus Microsphaera. Nomura & al. (1978, p.304, + Tab. 4 and fig. 3, 5-8) described and illustrated this fungus as Microsphaera spec. The new species is allied to M. clethrae, but differs by fewer appendages and larger ascocarps. The closely related M. staphyleae Sawada possesses larger ascospores.

3. Microsphaera orixae U. Braun & S. Tanda spec. nov.

Syn.: M. alni auct. p.p.

Mycelium amphigenum, saepe epiphyllum, subpersistens. Cleistothecia sparsa vel subgregaria, (60-) 75-100 (-110) µm diam., cellulae peridii irregulariter angulatae, ca. 8-25 µm diam., appendices (3-) 5-18, diametro cleistothecii 1-1.5 plo longiores, ca. 65-135 µm, 0-2 (-4) septatae, hyalinae vel ad basim brunneae, superne tenui-, inferne crassitunicatae, ad basim 6-11 µm latae, ad apicem dichotome ramosae (3-6, saepe 4-5 x), ramis ultimis recurvatis, asci 2-5, 40-65 x 30-50 µm, ascosporae 3-6, saepe 4-5, ellipsoideae - ovoideae, 14-25.5 x 8-14 µm. Fig. 3.

Holotypus: hospes - Orixa japonica Thunb., Japan, Ya-

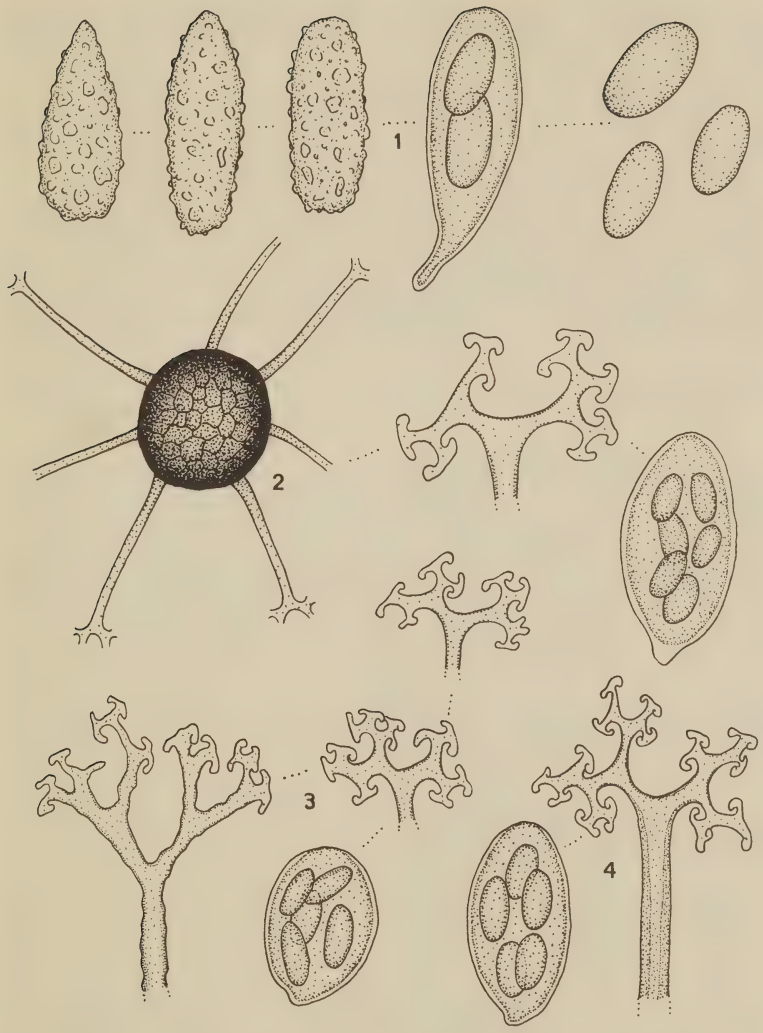

Fig. 1-4. Leveillula simonianii (1), conidia, ascus, ascospores. Microsphaera itoana (2), ascocarp, branched part of an appendage, ascus. M. orixae (3), apical parts of appendages, ascus. M. paederiae (4), ascus, apical part of an appendage. U. Braun del.

makita-machi, Kanagawa Pref., 18-10-1984, S. Tanda (TUAMH 2613). Isotypus: HAL. Paratypi: on Orixa japonica, TUAMH 0849, 1819, 2026.

The mycelium is white, effused or forms irregular patches. The cleistothecialappendages are fairly stiff, straight to curved, the wall is occasionally moderately thick throughout, the branchings are regular and close, primary branches often somewhat longer. The asci are sessile or shortly stalked. I observed some ascocarps with rather abnormal appendages. They were somewhat undulate-subnodulose, branchings very loose, somewhat diffuse (fig. 3). The new species is well characterized by very small ascocarps, robust appendages with septa and coloured basal parts. These features clearly distinguish this species from all related taxa.

4. Microsphaera paederiae S. Tanda, Y. Nomura & U. Braun spec. nov.

Syn.: M. alni auct. p.p.

Mycelium saepe epiphyllum, persistens. Cleistothecia 108-143 µm diam., cellulae peridii irregulariter angulatae, appendices 8-16 (-19), diametro cleistothecii ca. 1-1.5 (-2) plo longiores, (110-) 151-211 (-250) µm, rigidae, hyalinae, vel ad basim brunneae, 0-1(-2) septatae, superne tenui-, inferne crassitunicatae, ad apicem regulariter dichotome ramosae (4-7, saepe 5-6 x), compactae, ramis ultimis recurvatis, asci 3-9, (53-) 58-73 x 33-48 (-53) µm, ascosporae (4-) 5-6, ellipsoideae, 23-30 x 13-16 µm. Fig. 4.

Holotypus: hospes - Paederia chinensis Hance (= P. scandens var. mairei), Japan, Mt. Takamizuyama, Tokyo, Oct. 20, 1967, S. Tanda (TUAMH 0045).

This fungus was described and illustrated by Tanda & al. (1973). It resembles M. akebiae Sawada (ascocarps smaller), M. menispermi Howe s.l. and M. schizandrae Sawada (smaller ascospores).

5. Microsphaera wallrothii U. Braun & S. Tanda spec. nov.

Syn.: M. alni auct. p.p.

Etym.: F. W. Wallroth, German botanist and mycologist.

Mycelium amphigenum, evanescens vel subpersistens, conidia non catenulata, ellipsoideae (-ovoideae, -subcylindraceae), ca. 30-45 x 14-22 µm. Cleistothecia sparsa (-subgregaria), 85-125 µm diam., cellulae peridii irregulariter angulatae, ca. 8-25 µm diam., appendices 3-12, rigidae, diametro cleistothecii 0.75-1.5 plo longiores, hyalinae, 0-1 septatae, superne tenui-, inferne crassitunicatae, ad basim ca. 8-10 µm latae, ad apicem regulariter dichotome ramosae (4-6 x), compactae, ramis ultimis recurvatis, asci (3-) 4-6 (-7), (40-) 45-65 (-70) x (25-) 30-50 (-55) µm, ascosporae (3-) 5-6 (-7), ellipsoideae -

ovoideae, subcylindraceae - oblongae, (16-) 18-28 (-32) x (8-) 10-16 (-20) µm. Fig. 5.

Holotypus: hospes - Vaccinium hirtum Thunb., Japan, Tsu-shi, Mie Pref., 1-11-1977, Abiko (TUAMH 2782). Isotypus: HAL.

The mycelium is effused or forms irregular patches. The cleistothecial appendages are very rarely trichotomously branched, smooth to usually rough. The asci are sessile or shortly stalked. This fungus was recorded by Abiko and Hagiwara (1980) under M. alni. M. alni s.l. is known in Japan on Vaccinium hirtum, smallii, usunoki, and versicolor var. glabrum. The new species is related to M. akebiae Sawada and M. schizandrae Sawada (appendages more numerous), as well as M. miyabeana U. Braun (primary branches often elongated).

6. Sphaerotheca euphorbiae-hirtae U. Braun & R. B. Somani spec. nov.

Syn.: Oidium euphorbiae-hirtae Yen, Rev. Myc. 31(4), p.296 (1966). O. pedilanthi Yen, Cahiers du Pacifique 11, p.104 (1967). O. pedilanthi R. Mathur, B. Mathur & L. Bhargavan, Ind. Phytopath. 24(1), p.63 (1971). O. cyparissiae auct. p.p. (ss. Narayanaswamy & Ramakrishnan 1969, p.86). Acrosporium cyparissiae auct. p.p. (ss. Subramanian 1971, p.837). Sphaerotheca fuliginea auct. p.p. (ss. Somani & al. 1976). Sph. euphorbiae auct. p.p. (ss. Rao 1961).

Mycelio amphigeno, albo, effuso, confluenti. Hyphis sterilibus repentibus, hyalinis, septatis, tenuitunicatis, ramosis, 4-10 µm crass., appressoriis mammatibus. Conidiophoris simplicibus, ex hyphis sterilibus oriundis, 50-250 µm longis, cellulis ad basim cylindraceis, rectis, 35-90 x 10-14 µm. Conidiis catenulatis (3-8), ellipsoideis - ovoideis, vel doliiformibus, (20-) 25-38 (-40) x (12-) 13-21 (-23) µm. Cleistothecia sparsa vel subgregaria, (70-) 75-100 (-110) µm diam., cellulae peridii irregulariter formatae, 15-40 µm diam., appendices mycelioideae, septatae, tenuitunicatae, hyalinae - brunneae, 4-11 µm latae, diametro cleistothecii 0.5-2.5 plo longiores, asci (immaturae) crassitunicatae, ca. 60-85 x 50-65 µm, ascosporae 6-8, subglobosae (-ellipsoideae), ca. 15-22 x 13-20 µm, vel asci (maturae) tenuitunicatae, ca. 70-130 x 65-80 µm, ascosporae ellipsoideae - ovoideae (-subglobosae), ca. 20-28 x 17-22.5 µm. Fig. 6.

Holotypus: hospes - Euphorbia hirta L., India, Akola, Nov. 1984, Somani (HAL).

This fungus, distributed in Asia on Euphorbia hirta and Pedilanthus tithymaloides, differs from all allied taxa by the features of the asci. The immature asci (content filled with oil drops) are thick-walled, the spores are small and mostly subglobose. The mature asci are characteristically elongated, ellipsoid - ovoid, very thin-walled. They rapidly swell in water and may reach a size

larger than the cleistothecial diameter. The mature ascospores are also large. The conidial state as well as the ascocarps on Pedilanthus agree with Sph. euphorbiae-hirtae entirely. I investigated two Indian samples on Pedilanthus with cleistothecia (IMI 209585, 254720).

7. Uncinula matsunamiana Y. Nomura, S. Tanda & U. Braun spec. nov.

Etym.: Y. Matsunami, Japanese mycologist and phytopathologist.

Mycelium amphigenum. Cleistothecia sparsa, 106-147 µm diam., cellulae peridii irregulariter angulatae, ca. 17-21 µm diam., appendices 11-16, diametro cleistothecii ca. 1-1.5 plo longiores, 146-243 µm, 1 septatae, hyalinae, tenuitunicatae, ad basim ± crassitunicatae, ca. 6-7 µm latae, ad apicem incrassatae et circinatae, asci 10-13, 59-70 x 36-40 µm, ascosporae 6 (-7), ellipsoideae - ovoideae, 19-25 x 11-16 µm. Fig. 7.

Holotypus: hospes - Rhus sylvestris Sieb. & Zucc., Japan, Hatunoso, Tokyo, Oct. 30, 1961, Y. Nomura (YNMH, herb. Nomura).

This fungus was described and depicted by Nomura & al. (1978, p.302, + Tab. 3, fig. 2). The new species differs from U. verniciferae, a common powdery mildew on numerous species of Rhus, by the features of the appendages. They are regular, not geniculate, the wall is thin or only slightly thicker near the base, and the width is increasing upwards. U. matsunamiana is related to U. kusanoi, but differs by very numerous, fairly large asci.

8. Uncinula viburni Y. Nomura, S. Tanda & U. Braun spec. nov.

Mycelium amphigenum. Cleistothecia sparsa, 75-120 µm diam., cellulae peridii irregulariter angulatae, ca. 10-23 x 6-13 µm, appendices 13-30, diametro cleistothecii ca. 1-1.5 plo longiores, 80-180 µm, ca. 5-7 µm latae, ad basim, ad apicem incrassatae, hyalinae, non septatae, superne tenui-, inferne crassitunicatae, ad apicem uncinatae - circinatae, asci 4-6, 45-57 x 38-40 µm, ascosporae 3-5, ellipsoideae - ovoideae, 20-25 x 10-14 µm. Fig. 8.

Holotypus: hospes - Viburnum dilatatum Thunb., Japan, Sagamiko lake side, Kanagawa Pref., Nov. 2, 1975, Y. Nomura (YNMH, herb. Nomura). Paratypus: hospes - Viburnum erosum Thunb., Japan, Kinomiya, Shizuoka Pref., Nov. 30, 1975, Y. Nomura (YNMH, herb. Nomura).

The scattered ascocarps are generally mixed with fruit bodies of Microsphaera sparsa Howe. The equatorial appendages are straight or curved, seldom flexuous, increasing from base to top, especially the apical part is conspicuously enlarged (ca 20-25 µm diam). The circinate part of the closely allied U. kusanoi is narrower (ca 17-20 µm

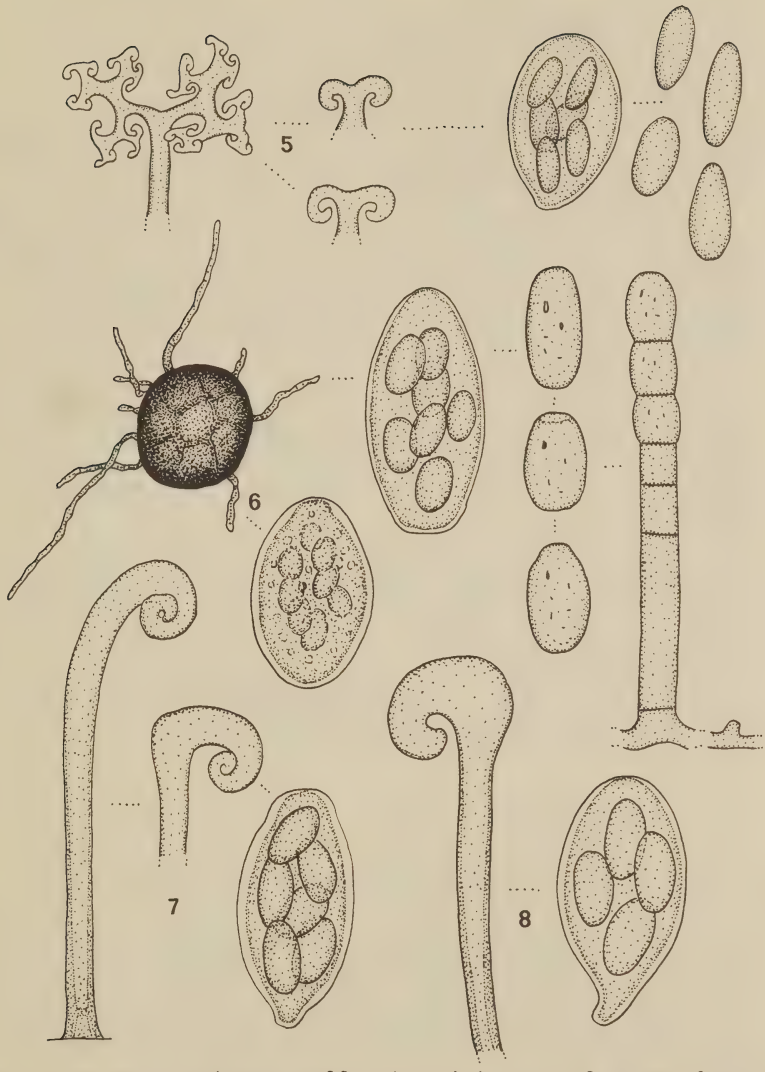

Fig. 5-8. Microsphaera wallrothii (5), apical part of an appendage and two ultimate branchlets, ascus and ascospores. Sphaerotheca euphorbiae-hirtae (6), ascocarp, two asci (mature and immature), conidia, conidiophore, appressorium. Uncinula matsunamiana (7), appendage, apical part of an appendage, ascus. U. viburni (8), appendage, ascus. U. Braun del.

diam). The Uncinula on Viburnum was described and illustrated by Tanda & al. (1977).

9. Oidium cinnamomi (Yen) U. Braun stat. nov.

Bas.: O. erysiphoides f. cinnamomi Yen, Cahiers du Pacifique 11, p.96 (1967).

Syn.: Erysiphe cinnamomi Sawada, Descr. Cat. Formos. Fungi I, p.144 (1919), nom. illeg. (ICBN, Art. 59).

Sawada (l.c.) described this Oidium on Cinnamomum camphora under Erysiphe. In 1959, he rejected this name and referred this fungus to Oidium alphitoides (= Microsphaera alphitoides). Yen (l.c.) discussed the Cinnamomum Oidium and pointed out the differences between f. cinnamomi and O. alphitoides (appressoria and conidial germination distinct). The perfect state of this fungus is unknown. Therefore, it should be considered as a species of the genus Oidium. Nomura (1981) described and illustrated an Oidium on Cinnamomum japonicum which is quite distinct from O. cinnamomi. It is distinguished by the structure of the conidiophores and the conidial shape. This fungus should be considered as a separate species of the genus Oidium.

10. Oidium cinnamomi-japonici U. Braun spec. nov.

Conidiophoris simplicibus, ex hyphis sterilibus oriundis, 90-150 x 8-12 µm, cellulis ad basim cylindraceis, rectis, conidiis solitariis, ellipsoideis - cylindraceis, 42-55 x 18-26 µm.

Holotypus: hospes - Cinnamomum japonicum Sieb., Japan, Nomura (YNMH 4894, herb. Nomura).

A photograph of this fungus was published by Nomura (l.c.).

11. Oidium schmiedeknechtii U. Braun spec. nov.

Syn.: Oidium spec. (Braun 1982, p.150, + fig. 26).

Etym.: Dr.M. Schmiedeknecht, German mycologist and phytopathologist.

Mycelio amphigeno, albo, indistincte effuso, confluenti. Hyphis sterilibus repentibus, hyalinis, ramosis, flexuosis, septatis, appressoriis lobatis. Conidiophoris simplicibus, ex hyphis sterilibus oriundis, cellulis ad basim cylindraceis, rectis, 30-40 x (5-) 7.5-10 µm. Conidiis solitariis, cylindraceis (- ellipsoideis), 35-46.5 x 12.5-20 µm.

Holotypus: hospes - Urena lobata L., Cuba, 1967, Schmiedeknecht No. 530 (JE).

The new species is entirely distinct from O. urenae Yen. The two Oidium species on Urena are not closely related.

12. Oidium stapeliae (Picbauer) U. Braun stat. nov.

Bas.: O. erysiphoides var. stapeliae Picbauer, Sborn. vysok. škol. zem. v Brne, ČSR, Fac. Lesn., D18, p.26 (1931)

There are two distinct conidial states on Stapelia. Oidium acrocladum Ferr. (= Ovulariopsis acroclada (Ferr.) Cif. & Corte) forms the conidia singly. This fungus maybe belongs to Leveillula (cf. Blumer 1967). Var. stapeliae is an Euoidium (conidia in chains, cylindric-doliform, 23-28 x 11-13 µm). The name O. erysiphoides must be rejected (nom. dub. et ambig., cf. Braun 1982 b).

13. Oidium nephelii Hadiwidjaja ex U. Braun spec. nov.

Syn.: O. nephelii Hadiwidjaja, Landbouw (Landbouwkundig Maandblad voor Indonesie) 22, p.253 (1950), without Latin description. O. erysiphoides f. nephelii (Hadiw.) Yen, Rev. Myc. 31(4), p.286 (1966), not valid, based on a nom. nud.

Hyphis sterilibus repentibus, hyalinis, ramosis, septatis, 4.8-8.4 µm crass., appressoriis lobatis. Conidiophoris simplicibus, ex hyphis sterilibus oriundis, cellulis ad basim cylindraceis, rectis, 27.6-50.4 x 6 µm. Conidiis solitariis, ovoideis - doliiformibus, (19.5-) 24-39.5 (-49) x (10-) 14-19 (-26) µm.

Holotypus: hospes - Nephelium lappaceum L., Indonesia, Bogor, Oct. 1949, Hadiwidjaja (Fac. of Agric. Sci., Bogor).

The species was described and illustrated by Hadiwidjaja (l.c.), but without Latin description. It infects leaves, fruits and inflorescences. The foot-cells are followed by 1-2 shorter cells, the appressoria are often paired, and the germ tubes arise from a conidial end, they are short to moderately long, terminating with a lobed appressorium.

14. Oidium caesalpiniacearum V. B. Hosagoudar & U. Braun spec. nov.

Hyphis sterilibus repentibus, hyalinis, ramosis, septatis, 2.5-8 µm crass., appressoriis non lobatis. Conidiophoris simplicibus, ex hyphis sterilibus oriundis, cellulis ad basim cylindraceis, rectis, ca. 30-55 x 5.5-8 µm. Conidiis solitariis, ellipsoideis - cylindraceis (- doliiformibus, - ovoideis), 24-43 x 11-20 µm.

Holotypus: hospes - Bauhinia spec., India, Bangalore, Karnataka, 1984, Hosagoudar (HAL).

The new species is well characterized by the appearance of the infections (hypophyllous, definite patches, infected parts of the leaves discoloured, yellow or brown patches). The appressoria are nipple-shaped or only slightly lobed. Oidium bauhiniae Gorter & Eicker, recently described from South Africa, is clearly distinguished by multilobed appressoria and a distinct appearance of the infections.

15. Oidium ipomoeae (Yen & Wang) U. Braun stat. nov.

Bas.: Oidium erysiphoides f. ipomoeae Yen & Wang, Rev. Myc. 37(3), p.138 "1972" (1973).

The Oidium on Ipomoea resembles the anamorph of Erysiphe convolvuli DC. The taxonomic status of the Ipomoea Oidium is, however, obscure. We do not know the perfect state. Therefore, it seems to be the best way to regard this fungus as a species of the anamorphic genus Oidium.

16. Oidium robustum U. Braun & E. Oehrens B. spec. nov.

Mycelio amphigeno, saepe epiphyllo, albo, indistincte effuso. Hyphis sterilibus repentibus, hyalinis, ramosis, septatis, 3-8 µm crass., appressoriis lobatis, conidiophoris simplicibus, ex hyphis sterilibus oriundis, cellulis ad basim cylindraceis, erectis, ca. 20-30 x 8-13 µm, conidiis solitariis, ± cylindraceis, 28-50 x 13-18 µm.

Holotypus: hospes - Maytenus boaria Mol., Argentina, Villa Tacul (near Llao-llao/Bariloche), 19-3-1984, E. Oehrens B. (HAL).

The appressoria are mostly multilobed; the foot-cells of the conidiophores are followed by 1-2 cells, the second cell is about as long as the foot-cell or longer, seldom shorter. This Oidium differs from all known conidial states on hosts of the Celastraceae by the structure of the conidiophores and their width.

17. Oidium araliacearum U. Braun & E. Oehrens B. spec. nov.

Mycelio epiphyllo, albo. Hyphis sterilibus repentibus, hyalinis, ramosis, septatis, ca. 2-8 µm crass., appressoriis non lobatis vel leniter lobatis, conidiophoris simplicibus, ex hyphis sterilibus oriundis, rectis, cellulis ad basim cylindraceis, ca. (20-) 25-35 (-40) x 6-12 µm, conidiis solitariis, cylindraceis, 30-55 x 13-19 µm.

Holotypus: hospes - Pseudopanax valdiviensis Gay, Chile, Isla Mancera, Valdivia, 1959, E. Oehrens B. (HAL).

The mycelium forms thin patches; the foot-cells of the conidiophores are straight or somewhat flexuous, followed by (1-) 2 (-3) shorter cells. The second cell is sometimes about as long as the foot-cell or even longer. There is no allied anamorphic state on hosts of the Araliaceae.

Acknowledgements

Sincere thanks are due to Dr. V. B. Hosagoudar (Coimbatore, India), Dr. Y. Nomura (Japan), Prof. Dr. E. Oehrens B. (Argentina), Dr. R. B. Somani (Akola, India), and Dr. S. Tanda (Tokyo, Japan).

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MYCOTAXON

Vol. XXV, No. 1, p. 271 January-March 1986

TYPIFICATION OF DIMEROMYCES ISOPTERUS (LABOULBENIALES)

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In the original paper describing *Dimeromyces isopterus* Kimbrough (Kimbrough *et al.*, 1972) indication of the nomenclatural type was omitted. Under Article 37.1 of the ICBN (Stafleu, 1983) this taxon is not valid. The original material consisted of fungal thalli from several colonies of *Reticulitermes flavipes* (Kollar) collected in the area of Gainesville, FL. The holotype of *Dimeromyces isopterus* (in Kimbrough, Morales, and Gouger. *Mycologia* 64: 388-389, 1972) is designated here from this material: FLAS F 54070, on *Reticulitermes flavipes* (Kollar), in decaying pine log, near Corey Village, University of Florida campus, Gainesville, Alachua Co., Florida, leg. R. J. Gouger and J. W. Kimbrough. In FLAS.

According to Article 45.1 of the ICBN (Stafleu, 1983) the date of valid publication of *D. isopterus* is the final date of fulfillment of all conditions for valid publication, that is, the date of this note.

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MYCOTAXON

Vol. XXV, No. 1, pp. 273-277 January-March 1986

NOTES ON CORTICIACEAE (BASIDIOMYCETES) XIV

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Abstract

The new genus Granulocystis with the type Phanerochaete flabelliradiata is described.

Introduction

Recently Burdsall (1985) published a monograph of the genus Phanerochaete and excluded some species which did not fit into his narrower concept of the genus. Among them was Phanerochaete flabelliradiata John Erikss.& Hjortst. which he transferred to Tubulicrinis, a well known genus with a very narrow circumscription and one of the most homogeneous taxa in Corticiaceae s.l.

The genus Tubulicrinis, as treated by Donk (1956), is easily definable by the presence of lateral (bi-rooted) cystidia with a narrow capillary lumen, most often strongly amyloid or at least greyish in Melzer. Similar cystidia occur in e.g. Litschauerella and Tubulicium, but these are thick-walled throughout and generally many-rooted. The morphology of the basidia also shows homogeneity in Tubulicrinis, although deviation in size occurs and in some species they develop into a dense cluster (e.g. borealis). Similar uniformity can be observed in the hyphal configuration. The hyphae are narrow, thin to moderately thick-walled, always with clamps, and in some exceptional cases with the differentiation of skeletal hyphae (e.g. gracillimus). Furthermore, in nearly all species of Tubulicrinis the fruitbodies consist of small, more or less aggregated tufts which give the impression of an odontioid appearance (good examples are effugiens and inornatus). Another characteristic which is often stressed is that the cystidia dissolve in 5-10 % KOH. This is true in most species but not all, and is sometimes only, or most easily, observed in fresh material. This latter phenomenon also occurs in P. flabelliradiata, although it is less pronounced and cannot be solely used to indicate affinity.

The description of a new genus to accomodate P. flabelliradiata seems justifiable since there is no appropriate place for it among genera in Corticiaceae s.l. Granulocystis is

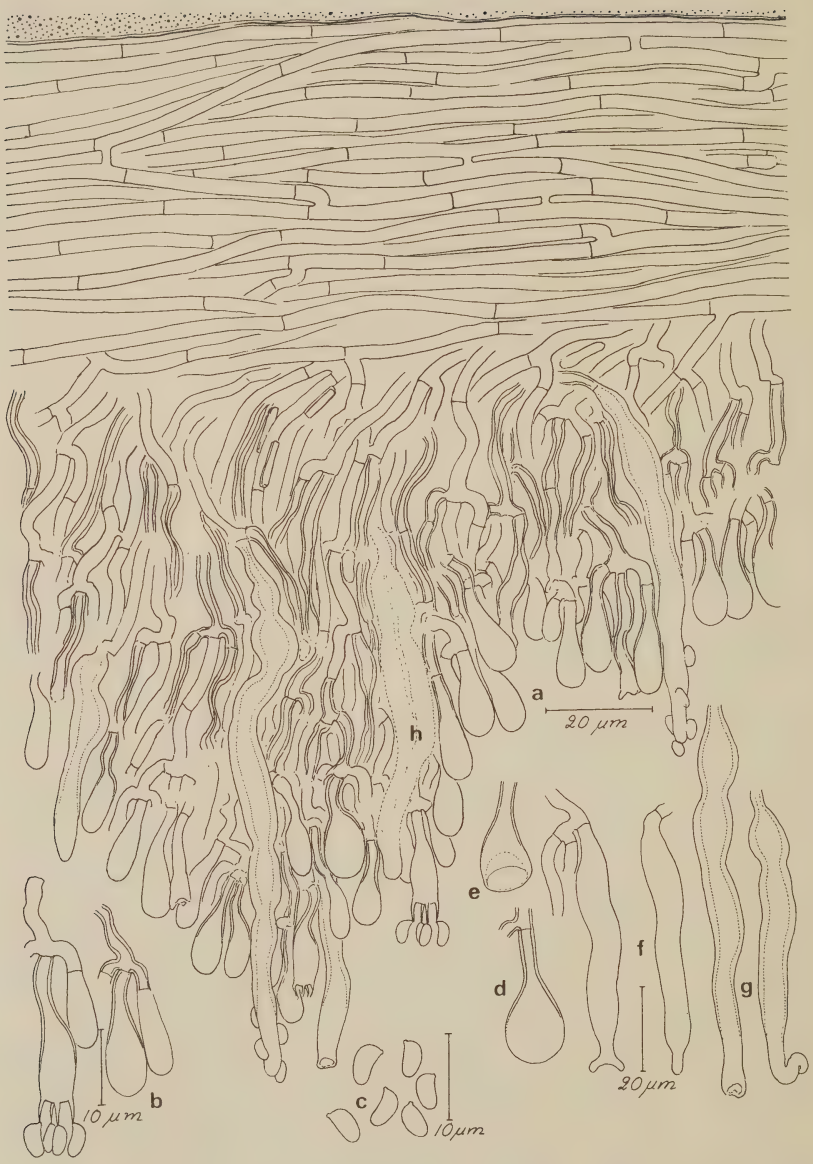

Fig.1 a) section through fruitbody b) basidia c) spores d) cystidioid basidium e) invaginated basidium f) young cystidia g) mature cystidia h) gelatinized cystidium.— Coll. Høgholen 945/77 (GB).

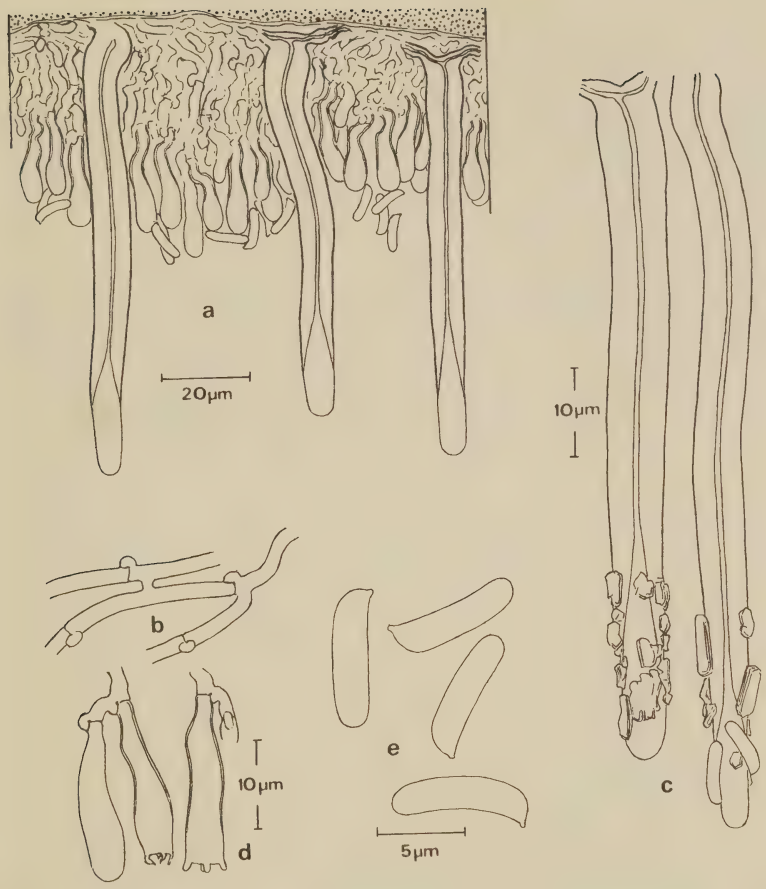

Fig.2 a) section through fruitbody b) basal hyphae c) cystidia d) basidia e) spores.— Coll. Holotype. Aug. 1885, J.B. Ellis (FH).

characterized by a combination of characters: the outward appearance of the type species is very distinctive and it is one of the very few corticiaceous fungi which is recognizable in the field thanks to the relatively large fruitbody, strongly fibrillose margin, and grandinioid appearance of the hymenium: it is monomitic with thin-walled hyphae: cystidia terminal, inamyloid, thick-walled except in the apical part: basidia more or less pedunculate: hyphae, cystidia, and basidia-walls swelling in 2% KOH.
It should be mentioned that this fungus, more than many others, is best studied from examination of fresh material. In a such material hyphae, cystidia, and basidia can be proper-

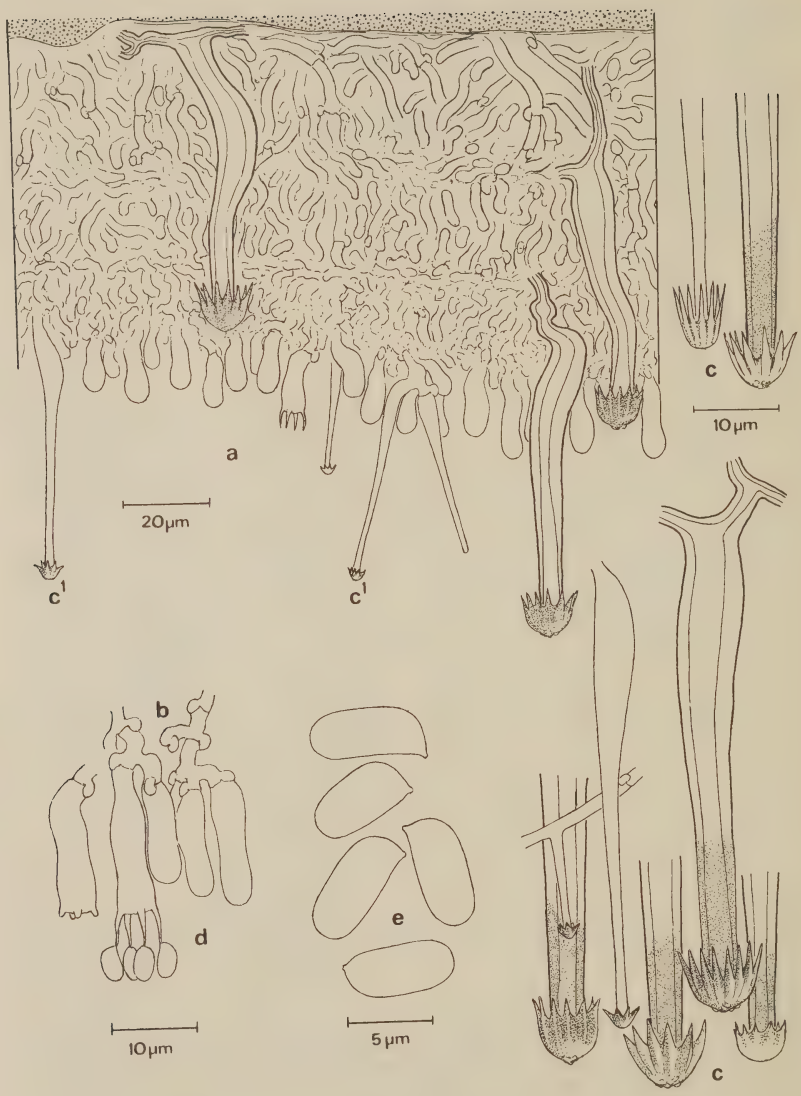

Fig.3 a) section through fruitbody b) subhymenial hyphae c) cystidia c¹) hymenial cystidia d) basidia e) spores. — Coll. a,b,d-e) Ryvarden 19104 (O) c) Cain 14569 (GB).

ly observed and scrutinized.

GRANULOCYSTIS Hjortst. gen. nov.

Fructificatio laxe adnata, effusa, mediocriter crassa; hymenium granulosum; margo distincte fibrillosus; systema hyphale monomiticum, omnes hyphae non-fibulatae, tenuitunicatae vel crassiusculae; cystidia terminalia, parietibus subgelatinosus, incrassatis, apicibus tenuitunicatis; basidia subclavata vel pedunculata, sine fibulis basalibus; sporae tenuitunicatae, leves, inamyloides, indextrinoides, acyanophilae.

Generic type: Phanerochaete flabelliradiata John Erikss.& Hjortst.

Generitype specimen: Norway.Akershus,Nannestad,Tømte Farm, west of Hurdal lake,250 m.a.s.l.,on Alnus incana. 1978-09-28. Leif Ryvarden 17494 (O).

Selected specimens examined: Canada.Ontario.1935-09-04.R.F. Cain. TRTC 8902 (part in GB). Norway.Hedmark.1977-09-03.E. Høgholen 491/77 (part in herb.Hjm):ditto 1978-07-19.E. Høgholen 341/78 (GB). Sweden.Västergötland.1970-09-04. Hjm 3541 (GB and in herb.Hjm). U.S.A. New Hampshire.1939-08-17.H.S. Eno.FP 84843 (part in GB).

Fruitbody loosely adnate, effuse, moderately thick; hymenium grandinioid and with the margin distinctly fibrillose; hyphal system monomitic, hyphae thin-walled to slightly thick-walled, in KOH with walls swelling, without clamps; cystidia terminal, thick-walled except in the apical part, walls swelling or dissolving in 2% KOH, inamyloid; basidia subclavate to pedunculate, basally thick-walled, with four sterigmata and without a basal clamp; spores ellipsoid, thin-walled, smooth, medium-sized (4-6 um long), walls inamyloid, non-dextrinoid and without cyanophilous reaction.

GRANULOCYSTIS FLABELLIRADIATA (John Erikss.& Hjortst.) Hjortst.comb.nov.

Basionym: Phanerochaete flabelliradiata John Erikss.&Hjortst. The Corticiaceae of North Europe Vol.6 p.1073, 1981.

For a comprehensive description of the species see Eriksson & al. loc.cit., and for comparison between Granulocystis and Tubulicrinis see fig.1 Granulocystis flabelliradiata, fig.2 Tubulicrinis gracillimus, generic type, fig.3 Tubulicrinis hamatus. Drawings by John Eriksson.

Acknowledgments

I am indebted to Dr. Derek Reid who has suggested improvments in the English text and to Prof. John Eriksson for preparing drawings.

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MYCOTAXON

Vol. XXV, No. 1, pp. 279-286 January-March 1986

SCYTALIDIUM JAPONICUM, A NEW SPECIES, THE CAUSAL AGENT OF CATTLE BRONCHIOLITIS

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SUMMARY

Scytalidium japonicum sp. nov. isolated from Japanese cattle and causal agent of bronchiolitis is described. It is characterized by dull green to greenish gray colonies on several agar media, and by having large hyaline arthroconidia and dark-colored, catenate chlamydospores.

Scant attention has been paid in the past to *Scytalidium* infections in medical and veterinary mycology. At present three species of the genus are known from clinical specimens and have been implicated in cutaneous or subcutaneous infections. The *Scytalidium* synanamorph of *Hendersonula toruloidea* Nattrass is the commonest species associated with hyphomycoses and has been recovered frequently from infections of skin and nails in humans. Most reported cases have occurred in the United Kingdom and involve former-natives of tropical countries now residing in that country (Gentles and Evans, 1970; Campbell, 1971; Campbell et al., 1973). More recently Mariat et al. (1978) described a verrucose dermatitis of the human face accompanied by onychomycosis from Algeria. In this case, the

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fungus was isolated from facial lesions and affected nails. *Hendersonula toruloidea* has been described as being widely distributed in tropical areas, where it is found as a wound parasite of citrus and stone fruit trees, including walnuts (Hughes, 1952; Ellis, 1971).

The second pathogenic species of *Scytalidium* is *S. hyalinum* Campbell et Mulder (1977). The first reported occurrence to this fungus was in patients of Jamaican and West African origin having skin and nail infections. It was noted to actively invade and grow in diseased tissues. Recently, Moore et al. (1984) encountered *S. hyalinum* infecting human skin in Spain.

A case of subcutaneous phaeohyphomycosis caused by *S. lignicola* Pesante was reported by Dickinson et al. (1983) from Florida. Prior to this, Dixon et al. (1980) reported the isolation of *S. lignicola* from sawdust samples collected in Virginia. Using hamsters, they recovered the isolate from homogenized spleen tissue 6-7 weeks after inoculation. It was concluded that the persistence of the fungus in an animal for that length of time represents an indication of potential pathogenicity. Dickinson and co-workers described their isolate as having two types of conidia; some hyaline and cylindrical, others yellowish-brown, thick-walled, barrel-shaped to broadly ellipsoidal. Conidial measurements given for both types match those of the type strain of *S. lignicola* but the reported shape of the pigmented conidia is somewhat different. Sigler (personal communication) found that this isolate produces pycnidia in culture after exposure to UV light. Further confirmation of its identity is needed.

One of us has recently encountered fungal bronchiolitis in Japanese black cattle bred at Kuga-machi, Kuga-gun, Hiroshima Prefecture. As a result of histopathological diagnosis conducted at the Yamaguchi-ken Chubu Livestock Hygiene Service Center, it was determined that affected animals had difficulty breathing. Upon death, isolation of a fungus from affected lung tissue of one animal was achieved by a direct plating technique onto Sabouraud's agar medium containing 0.5% yeast extract in June 1984. The fungus was identified as belonging to the genus *Scytalidium*. Of particular interest is the fact that this is the first case of a deep form of *Scytalidium* mycosis characterized by pulmonary infection. This agent appears to perhaps have a greater capacity to adapt to a tissue environment than the related species, and has a greater potential virulence. Etiological and pathological findings in two cases of the disease have been reported in

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Page 280 line 33 *for* Hiroshima *read* Yamaguchi

detail elsewhere (Takeya et al., 1985). The purpose of this paper is to describe cultural characteristics of the isolate and to establish a new binomial to accommodate it.

Scytalidium japonicum Udagawa, Tominaga et Hamaoka, sp.nov. (Figs. 1-4)

Coloniae in agaro decocto tuberorum post 14 dies et 23°C, 4.3-4.8 cm diam., effusae, floccosae, constantes ex mycelio coacto crassiusculo et conidio abundanti, plus minusve radiatim sulcatae, subolivaceo-griseae vel obscure virides vel viridi-griseae.

Mycelium saepe fasciculatum vel torsivum, ex hyphis hyalinis vel subbrunneis, ramosis, laevibus vel asperulatis, septatis, 1.5-6.0 µm diam. compositum. Cellulae conidiogenae a hyphis indistinctae, hyalinae vel subhyalinae, intercalares vel terminales, cylindraceae, fragmentantes et arthroconidiae formantes. Conidia duobus modis formantur: altera arthroconidia holothallica, catenata, sicca, simplicia, aseptata vel interdum uniseptata, hyalina, cylindracea, utrinque truncata, interdum clavata vel pyriformia, basi truncata et apice rotundata, raro T-formia, 9-22(-26) × 4.5-6.5 µm, interdum usque 18-35 µm longa (ubi uniseptata), tenuia et laevia, facile fragmentantia; alterae chlamydosporae pallide vel valde brunneae, catenatae, in hyphis gerentes, intercalares vel terminales, subglobosae, 7-10 µm diam., vel ovoideae vel oblongae, 5.5-18 × 4.0-6.0 µm, incrassatae et paene laeves, aegre secedentes.

Holotypus NHL 2954, isolatus e bronchiolo bove, Yamaguchi, in Japonia, in 2.vi.1984, leg. K. Tominaga. In herb. NHL.

Etymology: refers to country of origin.

Colonies on potato-dextrose agar growing rapidly, attaining a diam. of 4.3-4.8 cm within 14 days at 23°C, floccose, composed of a rather thick mycelial felt, more or less radially furrowed, Pale Olivaceous Grey (Rayner, 1970) or dull green to greenish grey (Methuen 30D3-2, Kornerup and Wanscher, 1978); conidiogenesis (both types) abundant; reverse Olivaceous Black (Rayner, 1970) or bluish grey (Methuen 24F3).

Colonies on phytone yeast extract agar (PYE) spreading broadly, attaining a diam. of 7.8 cm within 14 days at 23° C, composed of a rather tough basal felt, radially furrowed, at first white, then becoming Pale Glaucous Grey (Rayner, 1970) or greenish grey (Methuen 25B2) in age, densely woolly; conidiogenesis sparse; reverse Umber to Isabelline (Rayner, 1970) or yellowish brown to brown (Methuen 5D5-7E4).

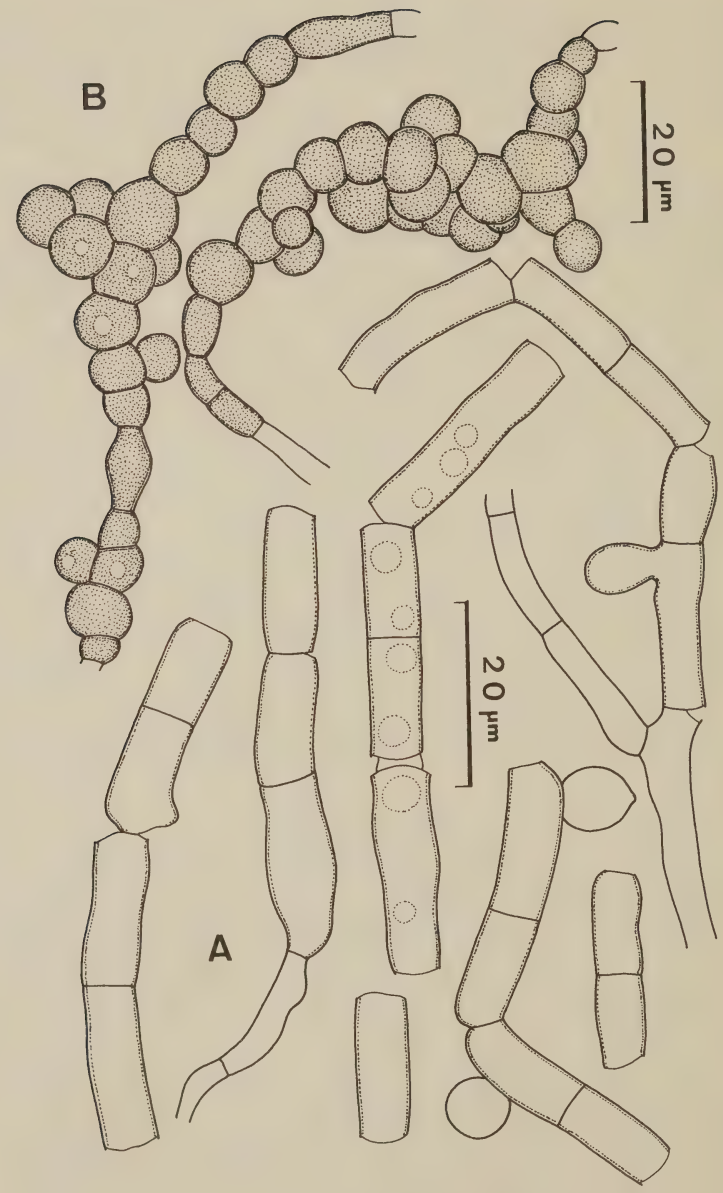


Fig. 1. *Scytalidium japonicum*.
A. Hyaline arthroconidia. B. Chlamydospores.

Colonies on malt extract agar spreading broadly, attaining a diam. of 6.8-7.0 cm within 14 days at 23°C, floccose, composed of a thin mycelial felt, at first white, then becoming Olivaceous Grey (Rayner, 1970) or dull green (Methuen 27E3); conidiogenesis abundant with hyaline arthroconidia predominant; reverse Iron Grey (Rayner, 1970) or greenish grey (Methuen 30F2).

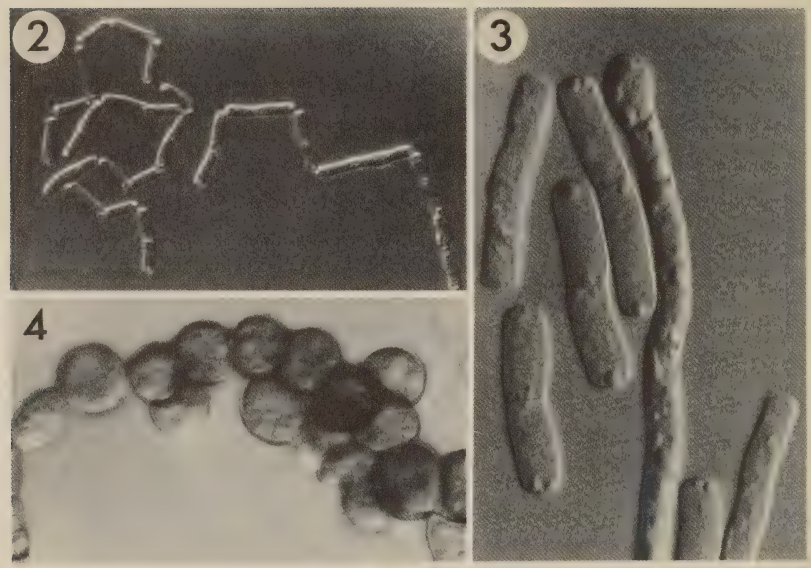
Colonies on Sabouraud's dextrose agar spreading broadly, attaining a diam. of 7.2-7.3 cm within 14 days at 23°C, thin, composed of submerged vegetative mycelium and prostrate hyphae, white to Vinaceous Buff Fawn (Rayner, 1970) or greyish orange (Methuen 6B3); conidiogenesis moderate but only hyaline arthroconidia produced; reverse Ochreus to Buff (Rayner, 1970) or greyish orange (Methuen 5B4).

Mycelium composed of hyaline to pale brown, branched, smooth to finely rough-walled, septate, 1.5-6.0 µm wide hyphae, often forming a bundle or spiral. Conidiogenous cells micronematous, hyaline to subhyaline, intercalary or terminal, cylindrical, fragmenting to form arthroconidia. Conidia of two kinds: (1) arthroconidia holothallic, catenate, dry, simple, 0(-1)-septate, hyaline, cylindrical, truncate at both ends, sometimes clavate to pyriform with a truncate base and rounded apex (when borne in terminal portion), or rarely T-shaped, 9-22(-26) × 4.5-6.5 µm or 18-35 µm long when 1-septate, thin and smooth-walled, seceding schizolytically and easily, and (2) chlamydospores, pale to dark brown, arising in chains in an intercalary or terminal position on short, lateral branches, subglobose, 7-10 µm in diam., or ovoid to oblong, 5.5-18 × 4.0-6.0 µm, thick and almost smooth-walled, not easily seceding.

Growth more rapid at 30°C than that at 23°C; at 37°C growth-rate is half to one-third that at 23°C, but sporulation occurs.

Type: NHL 2954, isolated from bronchiolus-lesion of domestic cow (*Bos taurus* var. *domesticus*, Japanese black cattle), Yamaguchi-ken Chubu Livestock Hygiene Service Center, Kagawa-ninowari, Yamaguchi City, Yamaguchi Pref., Japan, 2.vi.1984, coll. K. Tominaga. Dried cultures deposited in herb. NHL. Living cultures from the type are deposited at ATCC and UAMH.

Our isolate was compared with *Hendersonula toruloidea* (UAMH 4755), *S. hyalinum* (UAMH 4069) and *S. lignicola* (UAMH 1502-ex type strain, and FF27-Kingström), and found to clearly differ from these species. The hyaline arthroconidia of *S. lignicola* are smaller, viz. 4-11(-14) × 1.5-3.5 (-4) µm, and shape and mode of formation of the dematiaceous ones are also distinct. *Scytalidium hyalinum* is char-



Figs. 2-4. *Scytalidium japonicum.*
2, 3. Hyaline arthroconidia. 2, ×400; 3, ×1000.
4. Chlamydospores. ×1100.

acterized by the production of hyaline arthroconidia only and hence its colonies are white on agar media. The conidia of *S. hyalinum* are also smaller, viz. 5-11 × 2-3.5 μm or 4-8(-10) μm in diam. Besides the presence of a pycnidial anamorph, *H. toruloidea* is distinguished from *S. japonicum* in that its arthroconidia are smaller, hyaline or brown, and rounded.

Scytalidium was originally erected by Pesante (1957), based on *S. lignicola* found on Italian planewood. The taxonomy of this genus was considered in some details by Sigler and Carmichael (1976), who gave summarized descriptions and photographs of 6 species including the arthroconidial anamorph of *H. toruloidea* and an additional note on *S. uredinicola* Kuhlman, Carmichael et Miller (1976), a species growing in aecia of *Cronartium fusiforme.* Since then there have been a number of reports on additional species of the genus; viz. *S. terminale* Rao et de Hoog (1975), *S. thermophilum* (Cooney et Emerson) Austwick (1976), *S. hyalinum* Campbell et Mulder (1977), *S. indonesiacum* Hedger, Samson et Basuki (1982), *S. allahabadum* Narain,

Srivastava et Mehrotra (1983), and *S. fulvum* Morgan-Jones et Gintis (1984). In culture, *S. thermophilum*, *S. indonesiacum* and *S. allahabadum* are peculiar by their thermophilous nature, having maximal growth at 50°C or above. *Scytalidium japonicum* can be separated from the remaining species, on the basis of its gray colony color and the large size of its hyaline arthroconidia. Although this new species well fits within the generic concept of *Scytalidium*, some questions concerning the taxonomy of this genus are still unresolved, as pointed out by Morgan-Jones et al. (1984).

ACKNOWLEDGMENTS

We wish to thank Prof. Gareth Morgan-Jones for reviewing the manuscript; and Ms Lynne Sigler for supplying the cultures of *Scytalidium lignicola* and others from the University of Alberta Mold Herbarium and Culture Collection.

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MYCOTAXON

Vol. XXV, No. 1, pp. 287-308 January-March 1986

ALTERNARIA THEMES AND VARIATIONS (22-26)

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PROLOGUS

In continuation of a series of papers primarily on *Alternaria* (Simmons 1981, 1982, and in press), five *Alternaria* anamorphs are described as new in conjunction with their teleomorphs, which are transferred into or described as new in a new genus, *Lewia* Barr & Simmons, typified by *Sphaeria scrophulariae* Desmaz. Each teleomorph-anamorph pairing is based on axenic ascospore-to-conidium cultures or, in one instance, on a conidium isolate that produces mature ascomata in culture.

VIII. PLEOSPORA /STEMPHYLIUM AND LEWIA/ALTERNARIA AS SEGREGATES FROM PLEOSPORA SENSU LATO

The name *Pleospora* Rabenhorst ex Cesati & de Notaris (1863) means different things to different mycologists. A broad concept includes characters of medium-sized ascostromata, bitunicate asci produced among pseudoparaphyses, and pigmented muriform ascospores -- a circumscription sufficiently loose as to include a multitude of heterogeneous and biologically unrelated fungi. To me the genus *Pleospora* comprises strictly those species that have hyphomycetous anamorphs of the genus *Stemphylium* Wallroth (1833) or that at least are teleomorphically very similar to the ascoma-ascus-ascospore developmental patterns found in the *P. herbarum* complex of species.

Maintaining other distinctive phaeodictyosporic generic groups, such as *Clathrospora* Rabenhorst (1857), *Leptosphaerulina* MacAlpine (1907), *Paraphaeosphaeria* Eriksson (1967), and *Pyrenophora* Fries (1849), inter alia, reduces somewhat the complexity and numerical bulk of *Pleospora Auct.* but leaves an increasingly dense, taxonomically intractable core of species.

Numerous taxa of this *Pleospora*-residuum are known to

have anamorphic states, and many of these are Hyphomycetes. Some of my own observations, beginning about 1965 and based on axenic cultures, have helped to establish recognition of the relationship between species of *Stemphylium* and members of the *P. herbarum* complex of teleomorphs -- five species originally (Simmons 1969), two additional (Simmons, in press), and several more under active consideration.

P. G. Crivelli, in his published doctorate dissertation (1983), came close to attacking another portion of the common anamorph-aversion syndrome by illustrating conidia of several distinct *Alternaria* states produced in cultures derived from isolated ascospores. He noted major stable differences among the anamorphs, then made an observation of unusual pertinence to teleomorph-anamorph studies, namely, that variation in morphology of the teleomorph source materials was insignificant. In his view, in other words, the conidial states were distinctive and separable but the teleomorphs were not. The structure of Crivelli's thesis program did not permit extended attention to the differences among his *Alternaria* strains. He used the name *Pleospora scrophulariae* (Desm.) Höhnel (syn. *P. infectoria* Fuckel) for all of the numerous specimen sources of his *Alternaria* isolates. (It may be noted, in passing, that Crivelli kindly refrained from commenting directly on the *Alternaria* portion of my own doctorate dissertation (Simmons 1952), produced when I knew considerably less about *Alternaria* and isolation safeguards than I do now, which contained teleomorph-anamorph conclusions that I have doubted and disowned for the past many years.)

The purpose of the following presentation is to add to the list of generic segregates from *Pleospora sensu lato*, using whatever teleomorphic distinctions are available and emphasizing the diversity of the anamorphs.

PLEOSPORA Rabenhorst ex Cesati & de Notaris (1863), Comment. Soc. Crittog. Ital. 1: 217. [nom. cons.]

Type: *P. herbarum* (Pers.: Fries) Rabenh., l.c.
= *Sphaeria herbarum* Persoon (1801), Syn. meth. fung., p. 78.
= *Sphaeria herbarum* Pers.: Fries (1823), Syst. mycol. II(2): 511. Sanctioned name; lectotype in [E]: E. Fries, Scleromyceti Sueciae no. 38 (EGS 34-082).

Anamorphosis: *Stemphylium* sp. [described and named as novel in Sydowia vol. 38, in press; **not** *S. botryosum* Wallroth].

Pleospora species of the *P. herbarum* group have

dark-walled unilocular ascomata generally in the size range of 0.5-1.0mm diam.; always densely pseudoparenchymatous when young, they become ascogenous rapidly (a few weeks) or slowly (several months) and mature either relatively thin-walled, somewhat collapsing (e. g., *P. herbarum*), or thick-walled, firm (e. g., *Pleospora* state of *S. botryosum*).

Asci, few or abundant per ascoma, develop from the ascoma base upward into a centrum of pseudoparaphyses; they become long clavate, ellipsoid, or subcylindrical and are conspicuously bitunicate; for the most part they are 8-spored, although 6-, 4-, 2-, or even 1-spored asci occur both in nature and in culture (with ascospore dimensions insignificantly to dramatically greater than are those of the usual 8-spored asci, a fact to be kept in mind when noting extraordinary spore sizes).

Ascospores have sturdy walls and septa, are practically equilateral, fundamentally 3-transverse-septate (4-segments; cfr. Wehmeyer 1961, p. 8-9, and Eriksson 1967, p. 342), muriform through the insertion of secondary transverse and longitudinal or oblique septa in all of the four initial segments. (All known species of *Pleospora* with *Stemphylium* anamorphs have the 3 primary entire septa and at least 4 additional transverse or (in end segments) Y-form series of septa; the largest ascospores now known for this group, those of *P. gigaspora* Karsten, have 9-12 such transverse septa.) Ascospores are essentially ellipsoid with ends more or less rounded, terete in transverse section, usually slightly swollen in the subapical segment, usually visibly constricted at least at major septa, smooth, and have walls pigmented in moderate shades of clear brown; the smallest ascospores known at present mature at about 30 x 13µm (*Pleospora* state of *S. majusculum* Simmons), the largest near 60 x 27µm (*P. gigaspora*).

The characters above define typical *Pleospora*. It is likely that there are species of the genus that will not yield an anamorph when brought into culture; but I predict that when any fungus fitting this *P. herbarum* group picture produces a conidial state, it will be a *Stemphylium*.

LEWIA Barr & Simmons, gen. nov. Pleosporaceae

Ascostromata globosa vel sphaeroidea, atra, glabra vel undulate setosa, parietibus tenuibus, apice rostellata. Asci subcylindrici vel subellipsoidei, recti vel curvati, bitunicati, (4-)8-spori. Ascosporae juventute subellipsoideae, inaequilaterae; maturitate subfusoideae, subclavatae, vel ellipsoideae, ad septa parum constrictae, 5(-6-7) septis transversis, 1-2 septis longitudinalibus in segmentis

transversalibus, et cellulis terminalibus septatis aut eseptatis. Anamorphoses species Alternaria Nees : Fries.

Typus: L. scrophulariae (Desm.) Barr & Simmons, comb. nov.; basionym: Sphaeria scrophulariae Desmazières (1834), Plantes crypt. Nord de la France, ed. 1, fasc. 15, no. 718 [printed exsiccata label with name and description].

Ascostromata are globose or sphaeroid, dark, thin-walled, apically papillate, smooth or (in culture) conspicuously setose.

Asci, few to many per ascoma, develop from the ascoma base upward into a centrum of pseudoparaphyses; they become subcylindric to subellipsoid, straight or somewhat curved (depending on proximity to ascoma wall), thin-walled, bitunicate, (4-)8-spored.

Juvenile ascospores are narrow-clavate or ellipsoid, usually inequilateral, becoming subfusoid, somewhat clavate, or ellipsoid, somewhat constricted at septa (median septum often comparatively weak and pale, with ascospore sometimes separating in halves at this site), maturing with 5(-6-7) transverse septa and 1-2 series of longitudinal septa through the 2 major central spore segments, end cells without septa, or with 1 longitudinal or oblique septum, or with a Y-form pair of septa.

Anamorphoses, when known, are species of *Alternaria* Nees: Fries.

The genus name *Lewia* is based on the monogram of Lewis E. Wehmeyer, mentor to both authors in their mycological salad days.

Derivation of *Alternaria* anamorphs from isolated, viable ascospores of "*Pleospora*" is well-substantiated. *Pleospora infectoria* sometimes is cited, Whitehead and Dickson (1952) used the name *Pyrenophora alternarina* for their source material, and recently Crivelli (1983) cited a dozen or more *Alternaria*-genic specimens as *Pleospora scrophulariae*.

Historically, an early publication of Gibelli and Griffini (1874), using the name *Pleospora alternariae*, has influenced opinion on the subject for over a century. Their study basically was intended to determine if L. R. and C. Tulasne (1863) were correct in assigning several different anamorphs to "*Pleospora herbarum*." (The Tulasnes had listed 13 names under "*Fungus conidiophorus*" and 2 under "*fungi pycnidium*.") Gibelli and Griffini studied growths from isolated ascospores in hanging-drop cultures and decided that there are two kinds of "*Pleospora herbarum*":

Pleospora sarcinula Gib. & Griff with a sarcinula [*Stemphylium*] and a pycnidial state, and *Pleospora alternariae* Gib. & Griff. with "*Conidia exacte Alternariam tenuem Neesii referunt*." Ascospores of their *P. alternariae*, as illustrated by them, have the same narrow-ellipsoid, basically 5-transeptate appearance as do those seen in *Lewia*, and the illustrated anamorph is of a "clumped branching chain" sort discussed below for at least one of the *Lewia-Alternaria* connections.

It has become apparent to me, through examination of many hundreds of isolates of chain-forming *Alternaria* species with relatively small to moderate-sized conidia, that there is a group of species with distinctive characters matching those of a few dozen isolates known to me from "*Pleospora*" ascospores.

Until now I have been reluctant to address this group from a taxonomic viewpoint, and for several reasons:

Firstly, the morphological variation of *Alternaria* conidia, even in a single chain (and much more so in the population of a colony several days old), almost defies descriptive communication; the problem is being approached with some hope of success by emphasizing the appearance of juvenile conidia, their patterns of development to maturity, and, when characteristic, the patterns of sporulation from single conidiophores (solitary, simple chains, weakly branching chains, complexly branching chains).

Secondly, isolates of many species of *Alternaria* tend to deteriorate in active culture, becoming non-sporulating, sectoring, or grossly mycelial -- conditions that can make critical comparison difficult or impossible. (Loss of sporulation in weak isolates may be retarded by using only low-sugar media such as a weak potato-carrot agar, hay decoction agar, or V-8 juice agar.)

Thirdly, I have found no convincing evidence that anyone has succeeded in obtaining an *Alternaria*-related teleomorph in axenic culture. (R. S. Bilgrami (1974) reported isolations from diseased tissue of *Marsilea quadrifolia* L. that yielded conidia of *Alternaria tenuis* Nees, and that produced ascomata of *Pleospora infectoria* Fuckel in the same culture tubes after about a month. I have been unable to establish contact with the author of the report or with an institution that might have a voucher of the material.)

I personally have not seen the slightest evidence of ascoma initiation in any of the isolates of "*Pyrenophora alternarina*" shared with me many years ago by M. D. Whitehead, in my own numerous isolates from collections of "*Pleospora infectoria*" sent to me by J. Webster, or in any

of the Crivelli isolates of "*Pleospora scrophulariae*," all of which are pertinent to this discussion. However, numerous 1-ascus and 1-ascospore isolates from ascomata (on *Digitalis*, UK) of a species similar to those just listed invariably have yielded a distinctive *Alternaria* species and well-formed protoascomata(?), which, however, have not produced asci; the species is discussed below as *Lewia photistica* ("enlightening"). And finally, an isolate of an *Alternaria* (from *Medicago*, Australia) has produced fully mature ascomata; this species is discussed below as *Lewia eureka* (an epithet perhaps linguistically suspect, but expressing the relief felt after many years of frustration).

All of the species of *Lewia* discussed here have small ascomata and ascospores, as compared with those of *Pleospora*. Ascospores of all of them are 5-6(-7) transversely septate; they would fit in the Wehmeyer (1961) scheme as components of *Pleospora* subsect. *Vulgaris* (end cells not septate beyond the 5-transverse stage) or subsection *Pleospora* (end cells variously septate beyond the 5-transverse stage). No attempt is made here to accommodate *Lewia* species in the Wehmeyer classification system, as his subsection criteria prove untenable on examination of the type specimens of two crucial species, namely, *P. scrophulariae* (subsect. *Pleospora* of Wehmeyer) and *P. infectoria* (subsect. *Vulgaris* of Wehmeyer); ascospores of both are found to have end-cell septa. Similarly, it is necessary to question Wehmeyer's suggested relationship that would derive typical *Pleospora* (e. g., *P. herbarum* and its distinctive *Stemphylium* anamorph) from species typical of *Lewia* (e. g., *L. scrophulariae* and its distinctive *Alternaria* anamorph). The specific as well as the overall differences are too great -- and certainly more fundamental than simply increase in size and septation of ascospores.

E. Müller (1951) and his student P. Crivelli (1983) have considered *P. scrophulariae* and *P. infectoria* to be synonymous; Wehmeyer (1961) and some others have treated them as distinct taxa. The interpretation of these two commonly-used names is basic to establishing *Lewia* and to discussing related anamorphs. We have examined type material of both; we conclude that two distinguishable species are involved. In addition, the *Alternaria* anamorph of each is distinguishable. Both species are present among the numerous "*P. scrophulariae*" specimens and derivative isolates that Prof. Müller and Dr. Crivelli have generously allowed us to handle. A third species among the Crivelli material, similarly labeled, also is separable, as is its *Alternaria* anamorph. It is emphasized that the voucher specimens from colleagues in Zürich, and parallel cultures

from them, are of exceptional importance in interpreting some of the teleomorph-anamorph pairs. They are discussed and cited below, along with other unique material.

An attempt to equate the novel teleomorphs with published names and type slides in the Wehmeyer files (at DAOM) and with my own records (EGS) has proved unsuccessful. All of them, therefore, are described as new species. (I have no illusions about the likelihood that one or more of these may have an earlier published name; but there are limits to good intentions where the morass of *Pleospora* nomenclature is involved. I will applaud any replacement by earlier names that can be attached unequivocally to species with *Alternaria* anamorphs.)

The *Alternaria* states of *Lewia* species have conidia that are totally beakless. Each conidium has some degree of apical taper associated with its elliptical, oval, or conical shape, but the distal cell of the fully-formed conidium is obtuse and certainly without a definable true beak. Secondary sporulation occurs to a limited extent (short, branching chains of half-a-dozen conidia per primary conidiophore) or it may be prolific (long, complexly branching chains of dozens of conidia per primary conidiophore). The connective between any two conidia always is a secondary conidiophore (pseudorostrum), which may be robust and long (as much as 2-5+ times as long as the conidium that produced it), or so short that it exists only as a conidiogenous area in a conidium tip, and thus is revealed simply as a pore in the otherwise scarcely differentiated conidium apex when the chain is broken.

Relatively long, geniculate, sometimes branching pseudorostra are a striking, often dominant feature of *L. scrophulariae* and *L. infectoria* anamorph sporulation in culture. Pseudorostra (and concomitant secondary sporulation) are produced less exuberantly in other species treated here, but they still are the invariable and characteristic conidium outgrowths from which secondary spores arise.

As is the case with types of *Lewia* spp. nov., I have reviewed scores of older type specimens in search of ones that might serve as types of the *Alternaria* anamorphs described herein. The sort of anamorphs characteristic of *L. scrophulariae* and *L. infectoria* turn up frequently among miscellaneous isolates from sources worldwide; I had expected to find several 19th Century names and types usable for these anamorphs, but have failed. The chances are good that these anamorphs have a distinctly different appearance in field material than they do in axenic culture. Until this question is resolved, there is no good reason for

selecting an old name just because it is old or just "might" prove suitable. I will delight in synonymizing my own new names in this group if further work justifies such action.

22. **Lewia scrophulariae** (Desm.) Barr & Simmons, comb. nov. Fig. 35.

= *Sphaeria scrophulariae* Desmazières (l. c.); lectotype in [FH]: exsicc. cit., 718, "...*Au printemps, sur les capsules dessèchées de la Scrophulaire aquatique*." (EGS 38-123).

= *Pleospora scrophulariae* (Desm.) Höhnel (1917), Sitzungsber. K. Akad. Wiss. (Wien), Math.-Natur., Abt. 1, 126:374.

Ascomata of the type are erumpent, becoming almost superficial on the host; scattered, subglobose to sphaeroid with a short, blunt, papillate beak; about 150-200µm diam., dark, smooth, thin-walled at maturity. Asci subcylindrical, straight or somewhat musiform, 120-140 x 13-18µm, usually 8-spored (sometimes 4-6), about 40 per ascostroma. Juvenile ascospores fusoid, obovoid, subellipsoid, inequilateral (almost flat on one side), early 3-transeptate (4-segmented), at which time initial longisepta are formed, then basically 5- and at maturity 5-6-7-transeptate; forming a single longitudinal septum completely through each of the 2 original central segments, then an oblique one in the apical (rarely basal) segment, a secondary oblique (yielding a Y-formation), and quite frequently a second series of longitudinal septa through the subapical spore segment and, fairly often, in both of the central quarter segments; yellow-brown becoming gold-brown, with slightly darker walls and septa (except for the initial median septum, which often appears fragile and almost hyaline); at full development, 23-25(-30) x 8-9µm, definitely constricted at median septum and slightly so at two other early transepta, ellipsoid in face view, inequilateral with a tapered basal quarter in side view. (See discussion in section 23. below for comparison with very similar *L. infectoria*.)

Anamorphosis: **Alternaria conjuncta** Simmons, sp. nov.
(Etym.: L., connected [with a teleomorph])

Ex culturis in agaro PCA descripta. Coloniae mycelio epiagaro lanoso, sparsim vel copiose conidiogenae. Conidiophora elongata, 5-6 geniculata, c. 150 x 4µm. Conidia ellipsoidea vel longiovoidea, erostrata, c. 30-45 x 10-12µm, aspera, aureobrunnea, 7 transverse et 1(-2) longitudine septata. Sporulatio in catenis simplicibus conidiorum 4-5

Fig. 35. Right, Lewia scrophulariae; left, Alternaria conjuncta; ex Types. Magn.: vertical bar = 50µm.

vel ramosis conidiis c. 30 aggregata. Habitatio typi in Pastinaca sativa L., Switzerland (pro teleomorphose). Typus: partes ex EGS 37-139 (ex cult. Crivelli ZT 9067, 2.6.1982) desiccatae et in [BPI] (holotypus) et pro isotypo saltem in [IMI] et [NY] conservandae.

Young colonies (5-7d.) in PCA plates have a somewhat open wooly texture with sparse to abundant sporulation that occurs on conidiophores arising directly from the surface of the agar or from aerial hyphae. Primary conidiophores are simple with a single apical conidiogenous locus, becoming elongate and geniculate at 5-6 or more loci, up to about 150 x 4µm. Conidia are ellipsoid to long ovoid in form and erostrate until secondary sporulation begins; primary conidia (the first produced in a chain) are larger than those produced later in the same chain, c. 30-45 x 10-12µm, conspicuously rough-walled, medium clear golden brown (darker later), with c. 7 transverse and one series of longitudinal and oblique septa (two longitudinal series in lower cells of largest conidia). Secondary conidiophores typically arise from the apical cell of a primary conidium and become as long as 100+µm, geniculate with 5-7 conidiogenous loci, and occasionally branched. Sporulation is in simple chains of 4-5 conidia (separated by pseudorostra) or in branching clumps of chains that tend to be restricted in development (commonly c. 20-30 conidia per clump).

23. **Lewia infectoria** (Fuckel) Barr & Simmons, comb. nov. Fig. 36.

Basionym: *Pleospora infectoria* Fuckel (1870), Jahrb. Nassauischen Vereins Naturk. 23-24: 132. [and in Fuckel (1869), Fungi Rhenani no. 2246, but as a nom. nud.]. Lectotype in [K]: Fuckel, Fungi Rhenani 2246 "*Ad secalis, Hordei et Tritici vulg. culmos aridos, frequens. Vere.*" (EGS 37-160).

Ascomata in the type are in linear groups, erumpent through the constricting linear host tissues; ellipsoid, 400-500 x 150µm in surface view, with a short, obtuse, papillate beak, dark, thin-walled at maturity. Asci subcylindrical, straight or somewhat curved or musiform, 105-125 x 13-16µm, usually 8-spored, about 300+ per ascostroma. Juvenile ascospores are sharply fusoid, sometimes sigmoid, becoming short-clavate, slightly flattened on one side, early 3-transeptate (4-segmented) when longitudinal septa are formed, then 5-transeptate and remaining so for practically all spores seen; forming a single longitudinal septum through each of the 2 original central segments and

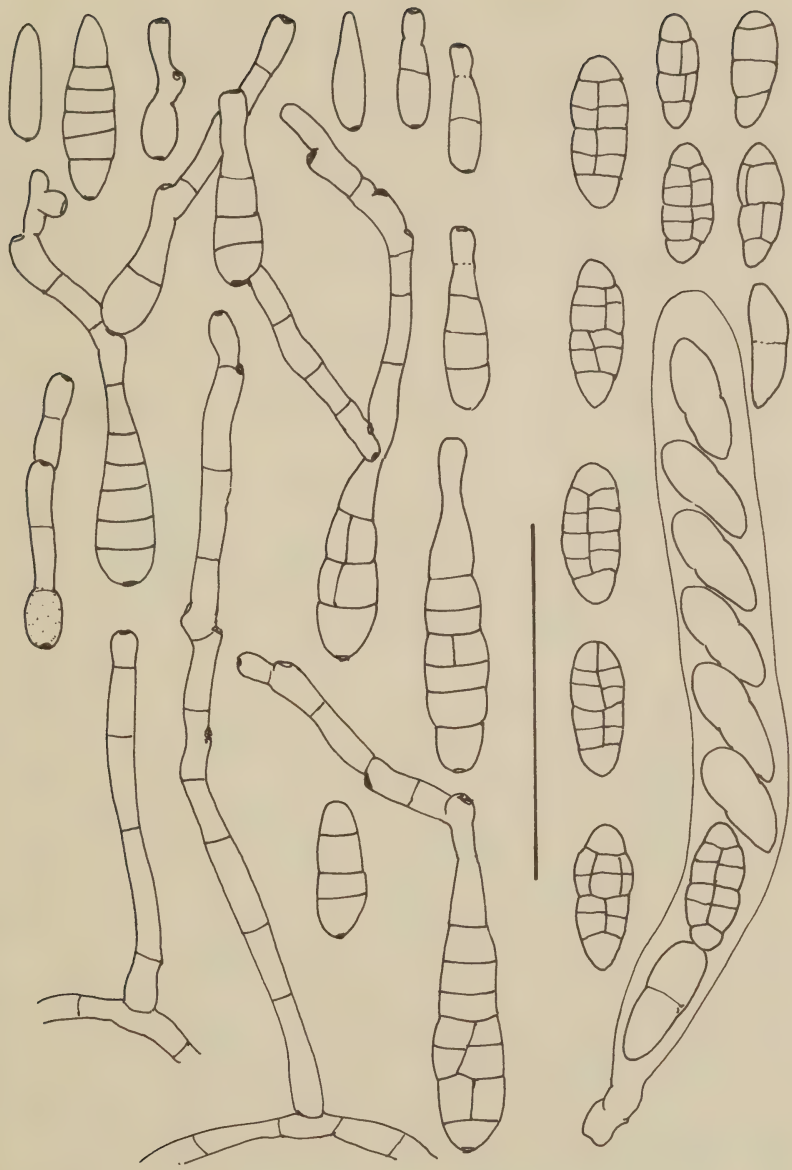

Fig. 36. Right, Lewia infectoria; left, Alternaria infectoria; ex Types. Magn.: vertical bar = 50µm.

rarely but definitely a second one longitudinally through either the upper central segment or the lower one (not seen in both concurrently); sometimes (uncommonly) forming a single vertical or oblique septum in the distal quarter of the mature ascospore; at full development, yellow-brown becoming gold-brown, with darker walls and septa (initial median septum often appearing weak and almost hyaline), 19-22 x 7-8µm, definitely constricted at median and slightly so at two other early transepta, subclavate, ellipsoid, often almost rhomboid in face view, very slightly inequilateral in side view.

Anamorphosis: **Alternaria infectoria** Simmons, sp. nov.

Ex culturis in agaro PCA descripta. Coloniae mycelio epiagaro laxe lanoso, copiose conidiogenae. Conidiophora elongata, 5-6+ geniculata, c. 125 x 3µm. Conidia longiovoidea vel ellipsoidea, ad 35-40 x 10µm, erostrata, longipseudorostratescentia, sublevia vel aspera, viridibrunnea vel brunnea, 6-7 transverse et parce longitudine septata. Sporulatio in catenis ramosis conidiis 40-50++ aggregata.

Habitatio typi in Triticum sp., UK (pro teleomorphose). Typus: partes ex EGS 27-193 (isol. EGS ex spec. J. Webster coll. et det., 16 May 1969) desiccatae et in [BPI] (holotypus) et pro isotypo saltem in [IMI] et [NY] conservandae.

Young colonies (5-7 d.) in PCA plates are loosely lanose and have very abundant sporulation from conidiophores that originate at the surface of the agar or from aerial hyphae. Primary conidiophores are simple with a single apical conidiogenous locus, becoming elongate and geniculate at 5-6 or more loci, up to about 125 x 3µm. Conidia are elongate ovoid or ellipsoid and erostrate until secondary sporulation begins; primary conidia are larger than those produced secondarily, c. 35-40 x 10µm, almost smooth-walled, medium clear greenish-brown (becoming somewhat rougher and a darker brown later), with 6-7 transverse septa and one longitudinal in only a few (1-3) of the transverse segments. Secondary conidiophores arise from the apical cell of primary conidia and become as long as c. 40-60µm, geniculate with 3-4 conidiogenous loci, and occasionally branched. Sporulation is in simple chains of 5-10 conidia (all pseudorostrate) or in branching clumps of seemingly unlimited complexity (commonly 40-50++ conidia), with secondary conidia often producing functional geniculate conidiophores from apical, lateral, or basal cells, often so rapidly that even 1- and 2-celled conidia become conidiophorogenous.

Discussion: *Lewia scrophulariae* and *L. infectoria*:

The complexity of ascospore septation progresses so gradually from that of *L. infectoria* to that of *L. scrophulariae* that it might seem almost trivial to insist on separate identities for the two taxa. Still, we believe that they are distinguishable species. Ascospores of *L. infectoria* typically mature at the smaller size observed for the two species and do not progress beyond the 5-transeptate stage (plus longitudinals); they are not conspicuously inequilateral. Ascospores of *L. scrophulariae* mature at the larger size of the two species and consistently advance into a 6-7-transeptate condition, commonly with pairs of longitudinal septa in central segments; they are conspicuously flattened/inequilateral, both as juveniles and at maturity.

It is not our present purpose to draw floristic conclusions about *L. scrophulariae* and *L. infectoria*; and it always is hazardous to make adamant statements when comparing unique field-collections as types. However, the ascoma source of typical *Alternaria infectoria* (*Triticum* sp., leg. J. Webster) fits the type distinction made above, as do P. Crivelli collections on *Elymus, Festuca, Lolium* (all Gramineae); Crivelli collections whose teleomorphs fit the *L. scrophulariae* pattern include at least material on *Pastinaca* and *Plantago*. Until considerably more material of this group has been studied in culture, it would be inappropriate to hold that *L. infectoria* is an inhabitant only of Gramineae and *L. scrophulariae* of dicotyledonous hosts. It is our opinion, however, that the type specimens, other collections cited, and their derivative anamorphs support the concept of two very similar but distinguishable species.

24. **Lewia ethzedia** Simmons, sp. nov. Fig. 37.
(Etym.: from acronym of "Eidgenössische Technische Hochschule, Zürich)

Ascomata subglobosa c. 150µm diam., atra, prope basin parce tomentosa, parietibus tenuibus, apice rostellata. Asci subcylindrici, recti vel submusiformes, 8-(rarius 6-) spori, 95-100 x 13-14.5µm.

Ascosporae juventute fusoideae vel subellipsoideae, inaequilaterae; maturitate late ellipsoideae vel inaequilateriellipsoideae, spadiceae, 5(-6) septis transversis, 1(-2) septis longitudinalibus in segmentis mediis transversalibus, interdum 1 septo longitudinali in 1-2 cellulorum termina-

lium, 19-21 x 8-9.5µm.

Holotypus in [ZT]: P. Crivelli no. 88.1.a "auf Brassica sp., Müllheim, ktTG, d.2.4.1981/[Kultur]ZT 9071." (EGS 37-178).

Ascomata of the type are erumpent, becoming almost superficial on the host, scattered, subglobose with a very small, blunt, perforate beak; about 150µm diam., dark, thin-walled, with a sparse basal tomentum of thick-walled brown hyphae. Asci are subcylindrical, straight to submusiform, 95-100 x 13-14.5µm, usually 8-spored (infrequently 6), 60+ per ascostroma. Juvenile ascospores fusoid to clavate or subellipsoid, inequilateral, early 3-transeptate (4-segmented), at which stage an initial longiseptum is laid down in each of the 2 central segments; 1 transeptum is added in each central segment, yielding a basically 5-transeptate spore with 1 series of longisepta in central segments. A high percentage of spores remain with this septation, but others add a single longitudinal or oblique septum in 1 or both of the end segments, rarely a 6th transeptum in the bottom segment of the spore, and sometimes a second longitudinal series in the widest central segment(s); at full development they are 19-21 x 8-9.5µm, constricted at 3 major septa, broadly ellipsoid to almost rectangular in face view, inequilateral-ellipsoid in side view, medium clear brown in color.

Anamorphosis: **Alternaria ethzedia** Simmons, sp. nov.

Ex culturis in agaro PCA descripta. Coloniae mycelio epiagaro arachnoideo vel laxe lanoso, sparsim vel moderate conidiogenae. Conidiophora elongata, 0-1-geniculata, c. 60-90 x 3-4µm. Conidia ovoidea vel subellipsoidea, erostrata, 35-45 x 10-14µm, pseudorostratescentia, subtiliter verruculosa, fulva, 7 transverse et 1(-2) longitudine septata. Sporulatio in catenis simplicibus conidiorum 2-6 vel parce ramosis conidiis c. 10-20 aggregata.

Habitatio typi in Brassica sp., Switzerland (pro teleomorphose). Typus: partes ex EGS 37-143 (ex cult. Crivelli ZT 9071) desiccatae et in [BPI] (holotypus) et pro isotypo saltem in [IMI] et [NY] conservandae.

Young colonies (5-7 d.) in PCA plates are arachnoid to loosely lanose with sparse to moderate sporulation on aerial hyphae. Primary conidiophores are simple, becoming 1-geniculate with 2 conidiogenous loci, up to about 60-90 x 3-4µm.

Conidia are ovoid to subellipsoid and erostrate until secondary sporulation begins; primary conidia (first-formed)

Fig. 37. Right, Lewia ethzedia; left, Alternaria ethzedia; ex Types. Magn.: vertical bar = 50µm.

c. 35-45 x 10-14µm, finely ornamented, fulvous (dull grey-yellow-brown), becoming rougher and darker, with c. 7 transverse and usually one series of longitudinal and oblique septa (sometimes 2 series in broadest transverse segments). A secondary septate conidiophore arises from the apical cell of a primary conidium and becomes as long as 30-40µm with 1-3 conidiogenous loci; other secondary conidiophores typically are 1-celled, c. 4-3µm. Sporulation is in simple chains of 2-6 pseudorostrate conidia or in loose clumps of sparingly branched chains with c. 10-20 conidia per clump.

25. **Lewia photistica** Simmons, sp. nov. Fig. 38.
(Etym.: latinized from Greek, meaning "enlightening")

Ascomata subglobosa, c. 300µm diam., atra, parietibus tenuibus, apice rostellata. Asci ellipsoidei, recti vel valde curvati, 8-spori, c. 130 x 21-23µm.

Ascosporae juventute ellipsoideae vel clavatae, inaequilaterae; maturitatae late obovoideae vel ellipsoideae vel inaequilateriellipsoideae, aureobrunneae, 6-7 septis transversis, 1-2 septis longitudinalibus in segmentis mediis transversalibus, vulgo 1 septo longitudinali vel Y-formi in 1-2 cellulorum terminalium, 21-22.5 x 11-13µm.

Holotypus in [BPI]: U. Allitt, "on last year's dead stems of Digitalis purpurea, April 1982, Cambridge [UK]." (EGS 35-172).

Ascomata in the type rare, scattered, erumpent, subglobose, c. 300µm diam., with a short, blunt beak, dark, thin-walled at maturity. Asci ellipsoid, straight, musiform, or strongly curved, c. 130 x 21-23µm, mostly 8-spored, c. 100+ per ascostroma. Juvenile ascospores ellipsoid to clavate, inequilateral, slightly pigmented at 1-cell stage and markedly yellow-tan by the time the initial median septum is formed; the locus of the first (median) septum is hyaline, contrasting with the developing pigment, and in strong contrast to the 2 transverse septa formed next, which already are dark at the 3-septate (4 segment) stage, as is the spore outer wall. Ascospores become 6-7 transeptate, with 1 or frequently 2 series of longisepta through both central segments, usually with oblique or Y-form septa in the top segment and commonly the same pattern in the bottom segment of the spore; at full development, strong golden brown with darker septa and spore wall (which are comparatively thick), 21-22.5 x 11-13µm, smoothly to sharply constricted at 3 major septa, broadly obovoid or ellipsoid in face view, inequilateral-subellipsoid in side view.

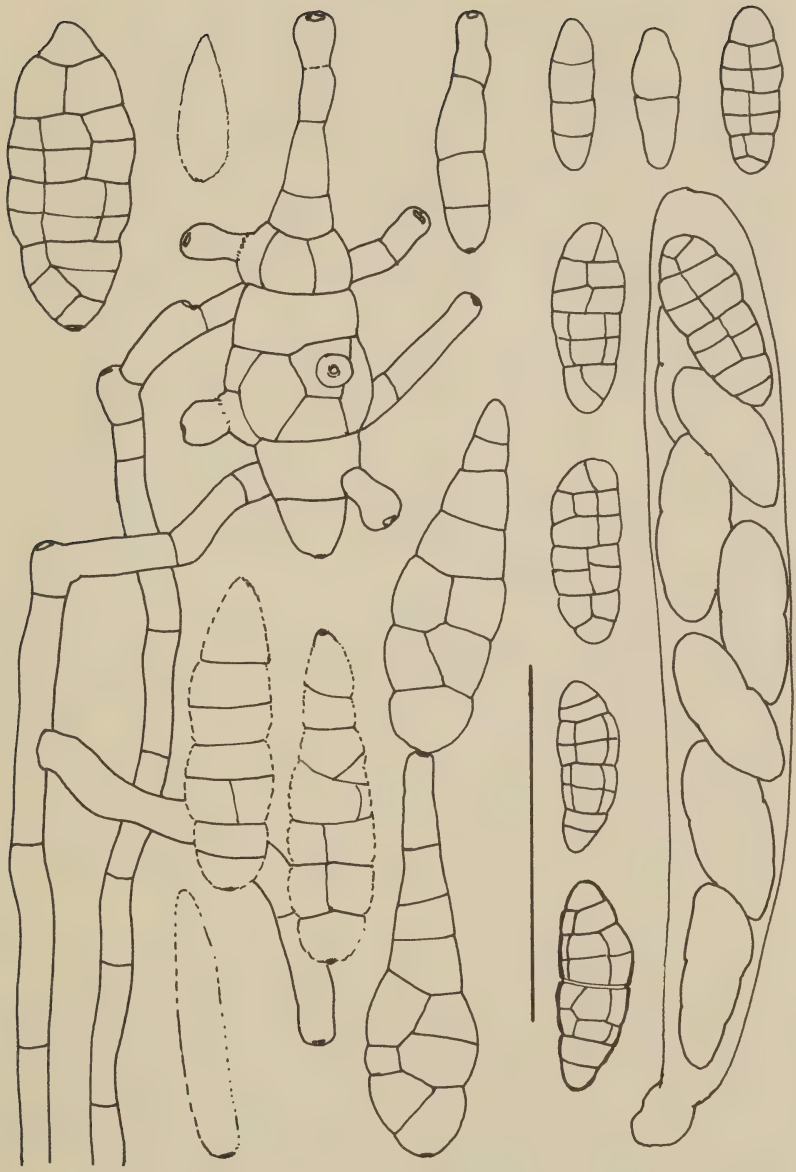

Fig. 38. Right, Lewia photistica; left, Alternaria photistica; ex Types. Magn.: vertical bar = 50µm.

Anamorphosis: **Alternaria photistica** Simmons, sp. nov.

Ex culturis in agaro PCA descripta. Coloniae mycelio epiagaro laxe lanoso et arachnoideo, sparsim vel dense fasciculate conidiogenae. Conidiophora robusta, ramosa, 1-5-geniculata, c. 150-170 x 4-5µm. Conidia longiellipsoidea vel obclavata, erostrata, c. 45-50 x 17-20µm, pseudorostratescentia, sublaevia vel parce verrucosa, fulva, 7-8 transverse et 0-2 longitudine septata. Sporulatio in catenis simplicibus conidiorum 3-6 vel multiramosis conidiis c. 16-20 aggregata. Protoascomata setosa, ascomatibus Lewia eureka similis.

Habitatio typi in Digitalis purpurea, UK (pro teleomorphe). Typus: partes ex EGS 35-172 (isol. EGS ex spec. U. Allitt coll., April 1982) desiccata et in [BPI] (holotypus) et pro isotypis saltem in [IMI] et [NY] conservandae.

Young colonies (5-7 d.) in PCA plates are sparsely lanose and arachnoid with sparse to densely clumped sporulation primarily on aerial hyphae. Primary conidiophores are robust, branched, geniculate at 1-5 conidiogenous loci, up to c. 150-170 x 4-5µm.

Juvenile conidia usually are long ovoid or sometimes almost cylindrical; mature primary conidia are c. 45-50 x 17-20µm, almost smooth to moderately verrucose, fulvous, with 7-8 transverse and 0-2 longitudinal or oblique septa in each transverse segment. Secondary conidiophores seldom are very long (c. 2-10 x 2-4µm), but as many as as 4-5 may be produced per conidium from lateral as well as apical cells. Sporulation is in simple chains of 3-6 conidia or in loose clumps of much-branched chains (16-20 conidia per clump); these loose clumps tend to merge with closely neighboring clumps, giving the impression of dense thickets of conidiophores and conidia.

26. **Lewia eureka** Simmons, sp. nov. Fig. 39.
(Etym.: fr. Greek *heureka*; an exclamation of triumph.

Ex culturis in agaro PCA descripta. Ascomata subglobosa vel ovoidea, 190-325 x 128-290µm, atra, parietibus tenuibus, setosa, apice rostellata. Asci clavati vel ellipsoidei, recti vel curvati, 8-spori, 104-112 x 16-21µm.

Ascosporae juventute subclavatae vel ellipsoideae, inaequilaterae; maturitatae late obovoideae vel ellipsoideae vel inaequilateraliellipsoideae, aureobruneolae, 5 septis transversis, 1 (raro 2) septis longitudinalibus in segmentis mediis transversalibus, et in segmentis terminalibus nullis, 26-27 x 10.5-11µm.

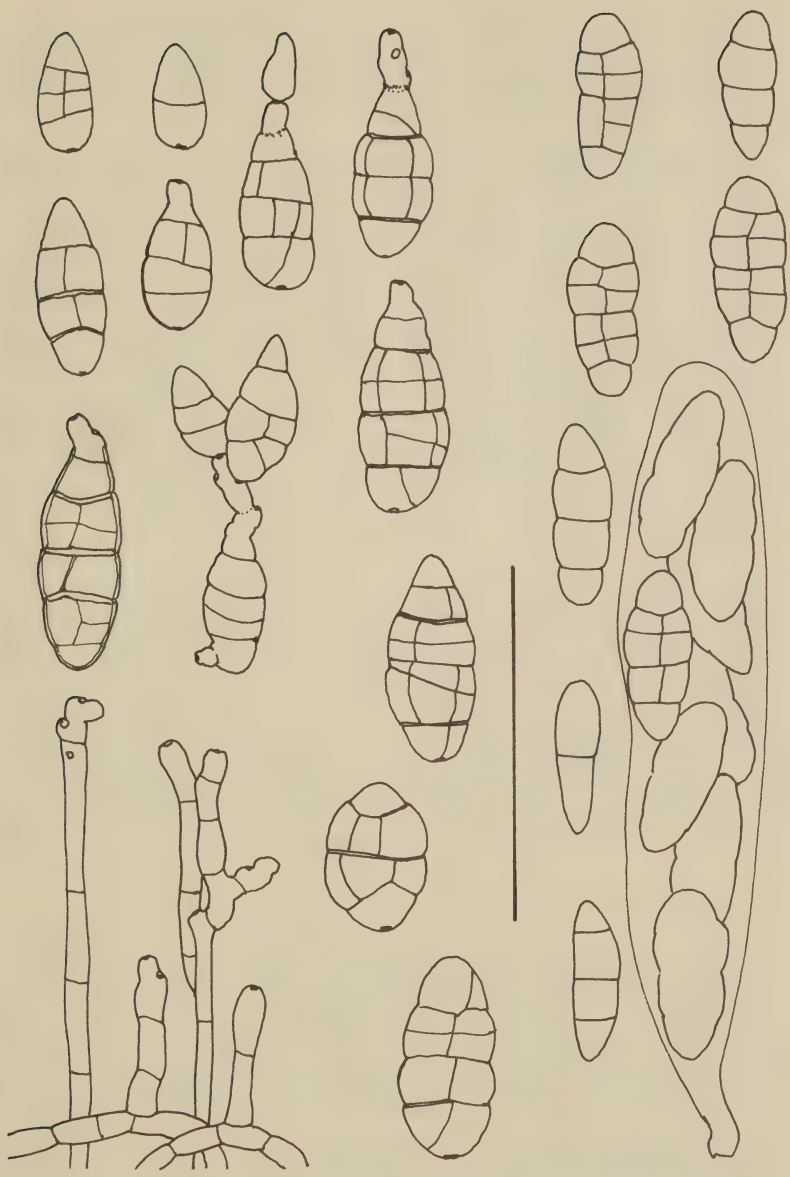

Fig. 39. Right, Lewia eureka; left, Alternaria eureka; ex Types. Magn.: vertical bar = 50µm.

Typus: partes ex EGS 36-103 (reisol. conid. EGS ex cult. IMI 273162, "from seed of Medicago rugosa c.v. Paragosa, Australia") desiccata et in [BPI] (holotypus) et pro isotypis saltem in [IMI] et [NY] conservandae.

Ascomata in PCA cultures ex Type are scattered, single, completely embedded or seated in the surface layer of the medium, subglobose or ovoid, 190-325 x 128-290µm (with mature asci) plus a small beak c. 25 x 25µm composed of short, fat cellular elements, dark brown, thin-walled at maturity. Numerous long septate setae arise approximately vertically from wall cells of those ascomata that are produced on the agar surface; they are dark, thick-walled, smooth or verrucose, and rigid near the base, tapering gradually to a hyaline, undulate, filamentous tip, 250-300µm in length, tapering from a 6µm diam. base. Protoascomata are visible in PCA cultures within 11 days, immature asci within 14 d., well-formed ascospores within 23 da., and fully mature within 29 days after inoculation. Asci are clavate to ellipsoid, straight or curved in the arc of the ascoma wall, 8-spored, 50+ per ascoma. Juvenile ascospores are subclavate to ellipsoid, inequilateral in side view, slightly pigmented at 2-cell stage, becoming 3-transeptate (4 segments), and maturing with 5 transverse and 1 series (rarely 2) of longisepta in the two central segments but without additional transverse, oblique, or Y-form septa in end segments; near maturity (23 d.), dull yellow-tan; at full development (29 d.), dull gold-green tan, 26-27 x 10.5-11µm, sharply constricted at median and moderately so at 2 other primary transverse septa, broadly obovoid or ellipsoid in face view, inequilateral-subellipsoid in side view.

Anamorphosis: **Alternaria eureka** Simmons, sp. nov.

Ex culturis in agaro PCA descripta. Coloniae mycelio epiagaro lanoso et arachnoideo, sparsim, inconspicue conidiogenae . Conidiophora tenuibus, vix ramosa, 1-4 arcte geniculata, c. 20-40 x 3µm. Conidia breviovoidea vel late ellipsoidea, erostrata, c. 15-30 x 12-13µm, laevia, fulva, 4-6 transverse et 1(-2) longitudine septata, interdum breviter 1-3 geniculate pseudorostrata. Sporulatio minute botryoidea conidiorum 5-6 aggregata.

Habitatio typi in Medicago rugosa, Australia. Typus: partes ex EGS 36-103 (reisol. conid. EGS ex cult. IMI 273162) desiccata et in [BPI] (holotypus) et pro isotypis saltem in [IMI] et [NY] conservandae.

Young colonies (5-7 d.) in PCA plates are moderately lanose and arachnoid with sparse, inconspicuous, minute clumps of sporulation mostly on hyphae just above the substrate surface. Primary conidiophores appear delicate and are poorly branched and closely geniculate at 1-4 conidiogenous loci; commonly c. 20 x 3µm, but sometimes elongate to c. 40µm.

Conidia are short ovoid or broadly ellipsoid, becoming c. 15-30 x 12-13µm, essentially smooth, fulvous, with 4-6 transverse and one longitudinal series of septa (sometimes 2 in widest transverse segments); conidium outer wall and major transverse septa are comparatively thick and dark. Secondary conidiophores have very restricted development; the first-formed (c. 3 x 3µm) is scarcely differentiated from the apex of the conidium that produced it, and a pseudorostrum with 1-3 closely geniculate conidiogenous loci measures only about 7 x 3µm. Sporulation is in tiny branching clumps of about 5 conidia.

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The availability of P. Crivelli's *Alternaria* isolates and the voucher specimens of their teleomorphs has been of great help in getting some ideas of long-standing into publishable form; I am most grateful to Dr. Crivelli and to Prof. E. Müller for their generosity. It is a pleasure to be able to publish results of many discussions shared with Prof. Margaret Barr Bigelow, who is included in the "we" when that pronoun is used in opinions given above. Numerous herbaria and contributors of specimens and cultures are cited in the text -- and are thanked warmly here.

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MYCOTAXON

Vol. XXV, No. 1, p. 309 January-March 1986

NOTICE

DEADLINE FOR PROPOSALS TO AMEND THE CODE OF BOTANICAL NOMENCLATURE AT THE XIV INTERNATIONAL BOTANICAL CONGRESS

The Nomenclature Section of the 14th International Botanical Congress will convene in Berlin, Germany, 20-24 July 1987, and will act on proposals to revise the Code (79 have already been published in *Taxon*). Further proposals may still be submitted and should follow the advice "Concerning Amendment Proposals" (Taxon 32: 660. 1983). Proposals should be sent to the editor of *Taxon* (Prof. F. A. Stafleu, Tweede Transitorium, Uithof, Utrecht, The Netherlands) as soon as possible and no later than 1 May 1986. This early deadline is required to ensure publication by November 1986, allow time for publication of the Synopsis of Proposals by February 1987, and permit completion of a Preliminary Mail Vote prior to the July 1987 meetings. Proposals received after 1 May 1986 will have to be deferred to a later Congress.

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MYCOTAXON

Vol. XXV, No. 1, pp. 311-320 January-March 1986

REVUE DES LIVRES

par

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Book Review Editor, Croix du Sud 3, B-1348 Louvain-la-Neuve
Belgique.

Mrs. Helena CRAMER informed us of the death of Mr. Jörg Cramer (01.12.1931 - 04.06.1985) in Braunschweig, Germany.

The editors of MYCOTAXON express to her, on behalf of MYCOTAXON readers, their sympathy and their gratitude for the important publishing services that J. Cramer provided to mycology.

We are pleased, once more, to review here another set of 12 books recently published by J. Cramer.

LES RUSSULES D'EUROPE ET D'AFRIQUE DU NORD, by Henri ROMAGNESI, 2nd edition with supplement, 1034 p., 1139 fig., 1 col. pl., 10 x 24 cm, cloth hardcover, 1985. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 250.-

The well-known monograph by Romagnesi is reprinted here exactly as it was edited by Bordas in Paris in 1967. But the reprint is supplemented by 32 pages of descriptions or redescriptions of 14 additional species, some of them new. The genus *Russula*, as presented by the author, is divided into 9 sections and 35 subsections and includes 203 species. The philosophy of Romagnesi's classification is fully detailed in the first two chapters (110 p.). After revision of the classification of Mulzer and Zvara, Schaeffer and Blum, Romagnesi agrees with the classification of *Russula* by Singer. We note the accuracy and completeness of the descriptions and the quality of the illustrations. The key to sections, subsections and species, 60 pages long, is in French and is also translated into English by R.W.G. Dennis. That will surely help in the use of the book by many more mycologists. The edition is of excellent quality. It is fortunate for mycologists that this monograph has been reprinted and revised.

UNTERSUCHUNGEN ZUR PRODUKTION UND REINIGUNG EINES GELBEN FARBSTOFFES DES BASIDIOMYCETEN PLEUROTUS OSTREATUS (JACQ. EX FR.) KUMMER, by Wolfgang MARGRAF, Bibliotheca Mycologica Band 93, 95 p., 33 fig., 14 x 23 cm, paperback, 1984. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 32.- (subscr.), 40.-

During investigations on *Pleurotus ostreatus*, in Prof. Eger-Hummel's Laboratory, an uncommon yellow orange pigment has appeared in mycelium

when fruiting was inhibited. The author has selected strains producing such a pigment under appropriate conditions. Glutamine, amongst amino acids, as nitrogen precursor, was shown most effective. The pigment was isolated, purified and proved to be a new kind of pigment, unstable in heat or oxygen, photosensitive, with a maximum absorption at 475 nm and a global formula $C_{35}H_{65}N_2O_{32}$. The author suggests, as a conclusion of his interesting work, that the pigment might play a role as a photoreceptor in the photomorphogenesis of the sporocarps.

ARTABGRENZUNG DURCH DNA-ANALYSE BEI EINIGEN VERTRETERN DER STROPHARIACEAE (BASIDIOMYCETES), by Klaus-Dieter JAHNKE, Bibliotheca Mycologica Band 96, 186 p., 25 fig., 14 x 23 cm, cloth hardcover, 1984. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 48.- (subscr.), 60.-

For the first time that, besides the determination of the guanidine-cytosine contents of the genome, DNA-DNA hybridization is applied in the Basidiomycetes in order to evaluate relationships at the species level. The author's aim is to test 23 species in *Stropharia* (11), *Psilocybe* (8), *Pholiota* (1), *Kuehneromyces* (1) and *Hypholoma* (2) represented by 38 strains, some from DSM Culture Collection. GC contents of these range from 42.2 to 45.9% while 4 species of *Polyporus* tested in comparison yield between 50.4 and 54.1%. The percentage DNA-DNA homology demonstrates, according to the author, the conspecificity of *Stropharia albocyanea* and *S. ochrocyanea* and of *Psilocybe squamosa* var. *squamosa* and *P. squamosa* var. *thrausta* (under the name *Stropharia thrausta*), as well as a close relationship between *Stropharia aeruginosa* and *S. caerulaea* (if the strains are properly identified). The morphological studies also presented are based on carpophores but are not related to all the strains tested, nor even concern species under biochemical investigation. Also half of the biochemically investigated species are not described morphologically from their original material. This study, however, is of interest as an application and a comparison of several new methods in biochemistry of fungi. Eventually, such studies contribute to fungal taxonomy, if the biochemist can be certain of the exact taxonomic position of material studied and assure its deposit in both an accessible herbarium and a culture collection.

ZUR ÖKOLOGIE DER MYKORRHIZAPILZE, by R. AGERER, Bibliotheca Mycologica Band 97, 160 p., 31 fig., 14 x 23 cm, paperback, 1985. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM : 48.- (subscr.), 60.-

This study is based on a 4-year survey of fruitbody production by 152 species of mycorrhizal fungi in two forest plots, 1200 m^2 by size, in a *Picea abies* forest on sandy and clay soil, and a similar plot on sandy soil under mixed *Fagus sylvatica* and *Quercus robur*, in south-west Germany. Every two weeks, the relative producivity of each species was recorded, in addition to the mean temperature and total precipitation. A correlation is demonstrated between spring temperatures and relative producivity later in the year, as well as to the amount of mycorrhizae in the soil during the spring. That correlation is striking in dry season and is slightly modified depending on precipitation. These

correlations may also differ according to the genus or species. Such careful studies advance our understanding of mycorrhizal development in forests.

LES PHYSALACRIACEAE DU GLOBE, by Jacques BERTHIER, Bibliotheca Mycologica Band 98, 128 p., 24 pl., 14 x 23 cm, paperback, 1984. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 40.- (subscr.), 50.-

The author reports his observations on 110 herbarium specimens assigned to the *Physalacriaceae*. In *Physalacria* he redescribes 25 known species, adds 3 species, 2 of which are new, and excludes 3 species. In *Hormomitaria* he redescribes 2 of the 3 species, transfering the third to *Mucorella*. He finally reduces *Pseudotyphula* to its type species. In this revision, Corner's delimitation of the family is maintained, but the presence of apically cyanophilous cystidia is emphazised. These cystidia may be found in hymenium or in sterile parts of the stem. They are thin or thick-walled and variously capitate or not. Other characters of the family are also listed. The author suggests that his observations should receive confirmation from studies of the same taxa in culture.

INDEX AGARICALIUM CHILENSIUM, by Norberto GARRIDO, Bibliotheca Mycologica Band 99, 340 p., 10 maps, 1 colour frontispice, 14 x 23 cm, cloth hardcover, 1985. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 96.- (subscr.), 120.-

This book is a compilation, based on about 250 bibliographical references, of the 764 Chilean Agaricales reported up to now. A taxonomic part presents taxa in alphabetical order. Synonymy, habitat, locality, observations, exsiccati and references are given for each species or infraspecific taxon. 686 species are accepted including 9 new combinations in *Astrosporina, Bolbitius, Entoloma, Favolaschia, Hypholoma* and *Leptoglossum* ; 78 species are listed as questionable. In a second part are indexes to all species and genera, to edible and poisonous species, to host names and synonyms, to ecological associations of the fungi and their hosts as mycorrhizal, parasitic or saprophytic, to Chilean type material of Agaricales, to European and North American species in Chile, to collectors' names and their exsiccati, in connection with a series of 10 maps and the coordinates of the collection sites. The book is completed by a list of about 250 references. This book will be useful in appreciating the contributions by Singer, Horak, Spegazzini, Epinosa, Lazo, Campo and others to Chilean mycology.

MYCOLOGISTS AND OTHER TAXA, by Martha SINGER, 120 p., 16 fig., 14 x 23 cm, paperback, 1984. Publ. J. Cramer, Braunschweig, Germany. Price : DM 20.-

Martha Singer, Dr. Rolf Singer's wife, recounts in detail her memories of her husband's travels and encounters with mycologists and "other taxa" of scientists through Vienna, Barcelona, Paris, Leningrad, Cambridge in USA, Florida, Tucuman in Argentina and Chicago. The text

is an apparently unedited and disorganized scrapbook of reminiscences, often told with humor, occasionally with thinly veiled rancor. Only Cramer would have accepted to publish a book of so little intrinsic merit.

LABOULBENIALES (FUNGI, ASCOMYCETES), by Isabelle I. TAVARES, Mycologia Memoir n°9, 628 p., 22 fig., 56 phot. pl., 14 x 23 cm, cloth hardcover, 1985. The New York Botanical Garden and the Mycological Society of America. Publ. J. Cramer, Springaeckern 2, 3300 Braunschweig, Germany. Price : DM 150.-

The Laboulbeniales, parasites on arthropods, are not always considered in mycological classes and many mycologists are not really acquainted with them, even if they know the famous study of them by Thaxter. In this ninth M.S.A. Memoir, Isabelle Tavares offers to us a well-done monograph of the Laboulbeniales. After an introduction and a history of knowledge on the field, the author describes the ontogeny of the thallus from the ascospore to the formation, fertilization and maturation of the new perithecium. Cell development is followed step by step, supported by a set of fine line drawings grouped at the end of the book. She also proposes her classification of the order, refering to Thaxter's old classification, and provides a key to 131 genera. She then revises every generic name, providing for each of them synonyms, sources of illustration, etymology, diagnostic characters, indication of the type, number of species, hosts and host species, and copious taxonomic comments, all supported by almost 300 bibliographic references. Many genera are illustrated by numerous black and white photographs. A phylogeny of the families is proposed. Geographic distribution is considered in relation to the parasitized hosts. The printing and binding by J. Cramer are of very high quality.

A CONTRIBUTION TO THE TAXONOMY OF THE GENUS PHANEROCHAETE (CORTICIACEAE, APHYLLOPHORALES), by Harold H. BURDSALL, Jr., Mycologia Memoir n° 10, 166 p., 46 fig., 14 x 23 cm, cloth hardcover, 1985. The New York Botanical Garden and the Mycological Society of America. Publ. J. Cramer, Springaeckern 2, 3300 Braunschweig, Germany. Price : DM 60.-

During the last few decades, many mycologists have devoted their efforts to the taxonomy of the old but difficult family *Corticiaceae*. Burdsall, one of them, had already regrouped more than ten, white rot producing, lignicolous, membraneous to crustaceous members of the family, with intricate textured subiculum in the genus *Grandiniella* Karst. *Phanerochaete* Karst. was later shown to be the correct name for the genus. The author therefore revised all available collections, to delimit 46 species within the genus, 16 of which are new combinations, and 2 are new species. He recognizes three subgenera, *Phanerochaete, Phanericium,* and *Scopuloides*, and presents dichototomic and synoptic keys to their species. These are treated in alphabetical order, with synonymy, description, illustration of microscopic features, list of specimens and comments. 14 excluded species are given with their correct names, synonyms and comments. Similar good contributions are awaited for many other genera of the *Corticiaceae* as revised by Eriksson et al.

AD POLYPORACEAS II & III, by E.J.H. CORNER, Beihefte zur Nova Hedwigia Heft 78, 222 p., 23 + 25 fig., 5 col. pl., 17 x 24 cm, cloth hardcover, 1984. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 96.- (subscr.), 120.-

In the first part, *Ad Polyporaceas II*, the author redefines *Polyporus* Fr. *sensu stricto* as having dimitic hyphae with skeleto-binding cells with terminals and lateral processes in the fruitbodies. The genus, retypified by *P. squamosus* instead of *P. tuberaster*, includes therefore *Favolus* and *Pseudofavolus* and shows relationship to *Lentinus*. *Echinochaete* differs particularly by spinose, brown cystidia. *Mycobonia*, with a smooth hymenium, can possibly be considered as an aporous *Polyporus*. Five new species, 3 varieties and 4 combinations are proposed in *Polyporus*, 7 new varieties in *Echinochaete*. Most taxa are tropical and described from living specimens. In the second part, *Ad Polyporaceas III*, the author precisely defines the hyphal system of the related genera *Piptoporus*, *Laetiporus* and *Buglossoporus*. The first is monomitic at first, then dimitic with generative hyphae bearing unbranched binding processes (*P. portentosus* and *P. cretaceus* excepted). *Laetiporus* has skeletal cells with many branched binding processes and *Buglossoporus* has skeletal cells or not, with a few sparingly branched or flabelliform, binding processes. Eight species, 3 varieties and one new combination in *Laetiporus* are proposed as new taxa. The affinity of *Bondarzewia* with previously mentioned genera is also discussed. Three new species are added in *Meripilus* and three new species in *Bondarzewia*. Most of the taxa described are from South-east Asia.

MITOCHONDRIALE MOSAIKGENE, Strukturaufklärung eines mobilen Introns aus dem Ascomyceten Podospora anserina, by Heinz D. OSIEWACZ, Bibliotheca Mycologica Band 94, 113 p., paperback, 1984. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 40.- (subscr.), 50.-

It is known that the senescence of *Podospora anserina* strains is controlled by mitochondrial DNA as well as by nuclear DNA. A plasmid like DNA isolated from mitochondria, cloned in *Escherichia coli* as vector and introduced in *P. anserina* protoplasts, caused early senility of cells. That pl DNA is characterized in the present work as an annular covalently linked DNA. At first integrated in mitochondrial DNA, it appears as a mobile intron that codifies cytochrome-oxydase I. After excision of the intron and ligation by covalence, a free plasmid is formed and can be replicated. The plasmids block the synthesis of maturase and of cytochrome-oxydase and therefore the cellular vital functions of mitochondria. The cell is then senescent. This work provides progress in fundamental comprehension of the common feature of senescence in fungi.

HOMOKARYOTISIERUNG VON BASIDIOMYCETEN, by Rainer DICKHARDT, Bibliotheca Mycologica Band 95, 136 p., 6 fig., 17 pl., 14 x 23 cm, paperback, 1985. Publ. J. Cramer, A.R. Gantner Verlag, FL-9490 Vaduz, Lichtenstein. Price : DM 40.- (subscr.), 50.-

Following the investigations by Leal-Lara (1980), the author, still under the guidance of Prof. Eger-Hummel, studied the monokaryotization effect of autoclaved glucose-glycine-containing culture media on dikaryotic strains of *Pleurotus ostreatus*. A labile compound is formed by autoclaving the medium, like a glycine-N-glucoside compound. Synthetized sodium glycinate-N-glucoside has indeed the same activity as N-acetylglucosamine, the effect of which is only partial. As the substance progressively disappears, dikaryotization is spontaneously restored in the culture. But cultures from monokaryotizised hyphal fragments yield neohaplonts. Similar results have been obtained in *Agaricus bitorquis* and *A. brunnescens*. The same compounds split dikaryons without clamps and even heterokaryons into neohaplonts similar to the homokaryotic parental types, nuclei being isolated into short or chlamydospore-like cells. Homokaryons have been obtained which fruited. Such strains might prove to be of practical interest. These interesting investigations also point to an important regulating factor in fungal morphogenesis.

TROPICAL PLANT DISEASES, par H. David THURSTON, 208 p., 59 fig., quarto broché, 1984. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minnesota 55121, U.S.A.

Cette publication est une intéressante approche du problème que causent les maladies des plantes aux cultures de basse altitude sous les tropiques. Ce n'est pas un traité de phytopathologie tropicale ni une revue technique des maladies, mais plutôt une évaluation de l'importance des principales maladies des plantes cultivées tropicales et des pertes qu'elles causent. De plus, ce livre veut aussi servir d'introduction à ces maladies qui ont ravagé et ravagent encore les grandes cultures tropicales,par la présentation d'une sélection de la littérature phytopathologique et d'ouvrages plus généraux sur chacune d'elles. En effet, dit l'auteur, le phytopathologue des tropiques connaît souvent plus les fléaux des cultures des régions tempérées que ceux qui l'entourent. Les principales céréales, plantes, racines et tubercules, légumineuses, bananes, plantes pour boissons (thé, café, cacao), plantes à huiles, canne à sucre, légumes ainsi que quelques plantes à usage industriel sont passées en revue et documentées de références sur leurs maladies. Treize maladies sont étudiées plus en détail. Ce livre, certainement, sensibilisera le lecteur à l'importance primordiale qu'il faut donner à la lutte contre les maladies des plantes sous les tropiques, de concert avec l'expérience des agriculteurs locaux.

COMPENDIUM ON PEANUT DISEASES, par D.M. PORTER, D.H. SMITH et R. RODRIGUEZ-KABANA, édit., The Disease Compendium Series (12ème fascicule), 73 p., 80 fig., 157 phot. couleurs, quarto, broché, 1984. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minnesota 55121, U.S.A. Price : US $ 14.- (members) 17.- (non members).

Ce nouveau Compendium, travail de 38 spécialistes, est, comme les précédents, une sorte de bible des maladies et dégâts de la culture envisagée, cette fois, de l'arachide. Parmi les principales maladies, 38 sont dues aux nématodes et 7 aux virus. Les désordres abiotiques comprennent les déficiences, les dégâts climatiques, les désordres

génétiques et surtout les dégâts par les agents polluants et phytosanitaires. Un intéressant chapitre est consacré aux agents symbiotiques, mycorhizes et rhizobia. Suit un chapitre sur les insectes nuisibles tant aux gousses en stockage qu'aux plantes sur pied. L'illustration est, comme à l'habitude, abondante et excellente et recouvre tous les cas étudiés.

COMPENDIUM ON PEA DISEASES, par D.J. HAGEDORN, édit., The Disease Compendium Series (13ème fascicule), 58 p., 16 fig., 110 phot. couleurs, quarto, broché, 1984. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minnesota 55121, U.S.A. Price : US $ 14.- (APS members), 17.- (non members).

Ici encore on retrouve la même qualité dans l'information et la présentation de ce Compendium. Celui-ci traite du pois, légumineuse alimentaire aussi ancienne que l'agriculture. Vingt-neuf maladies sont décrites. Trois sont bactériennes, dix-neuf sont fongiques et attaquent principalement la partie aérienne, tels *Mycosphaerella pinodes, Ascochyta pisi* et *Phoma medicaginis* var. *pinodella*. D'autres maladies du système radiculaire sont importantes aussi, dues à *Fusarium, Aphanomyces* et *Pythium*. En plus de quelques viroses, les dégâts par nématodes et les désordres de nature abiotique sont décrits. Cependant, les insectes prédateurs ne sont pas traités. Ces Compendia de l'APS sont d'un grand intérêt pour les praticiens de toute région agricole du monde et peuvent rendre de grands services à l'enseignement.

THE DUTCH, FRENCH AND BRITISH SPECIES OF PSATHYRELLA, par E. KITS VAN WAVEREN, Persoonia Supplement n°2, 300 p., 448 fig., 17 x 24 cm, broché, 1985. Rijksherbarium, att. Miss M. van Zoelen, P.O. Box 9514, 2300 RA Leiden, Netherlands. Prix : NFl 92.50.-

Le genre *Psathyrella* (Agaricales) n'a pas été récemment revu. Cette monographie, bien que limitée à une partie de l'Europe occidentale, est bienvenue. Bien que l'auteur veuille présenter un guide pratique d'identification et éviter de s'apesantir sur des détails d'anatomie, de structure ou de colorations chimiques, ses descriptions de 123 espèces et variétés reconnues et ses clés témoignent d'une grande précision. Le genre est divisé en deux sous genres : *Psathyrella* comprenant 5 sections et 38 taxa et *Psathyra* avec 7 sections et 85 taxa. Chaque description de taxon se base sur les récoltes mentionnnées de Hollande et d'Angleterre et s'accompagne de dessins de carpophore, de spores, basides et cystides, d'une synonymie, de références aux descriptions et illustrations publiées et aux erreurs d'identification et de commentaires taxonomiques. Résultat de plus de 20 ans d'observations, de récoltes et d'analyses méthodiques de celles-ci, réalisées dans les temps libres, laissés par une activité médicale chargée, ce livre sera d'autant plus apprécié.

KÜKENS CATALOGUE-CULTURES OF MICROORGANISMS, by Enver Tali CETIN, 74 p., paperback, 1982. University of Istamboul, Istamboul Faculty of Medicine, Center for Culture Collections of Microorganisms (KÜKENS), Capa, Topkapi, Istambul, Turkey.

Created in 1979, the Center KÜKENS has as its aim to keep medically important microorganisms and to maintain genetically standard cultures of microorganisms for biotechnology in culture collections. The institute promotes research on these microorganisms, organizes training sessions and international symposia. It publishes bulletins in microbiology and in mycology and other scientific papers. In 1982 the Collections maintained 246 yeasts and molds, 930 bacteria, 7 protozoa, 16 viruses and 3 cell cultures. The acronym of the Collections is KUEN.

JCM CATALOGUE OF STRAINS, par Kazuo KOMAGATA, édit., 2ème édition, 263 p., quarto, broché, 1984. Japan Collection of Microorganisms, Institute of Physical and Chemical Research, (Riken), Wako, Saitama, 351-01, Japan.

La création, en 1974, au Riken de l'office de la promotion des Sciences de la vie eu pour résultat la création de la Japan Collection of Microorganisms et sa reconnaissance comme collection nationale. La Collection JCM n'eut pas comme seules tâches la caractérisation, la maintenance et la distribution de microorganismes, mais aussi une fonction de recherche, de développement technologique et de formation. Ce ne fut qu'après 10 ans qu'elle publia son premier catalogue, en 1983. Cette première édition fut très tôt épuisée et remplacée par cette seconde édition. 2417 souches de bactéries, actinomycètes, moisissures et levures. La majeure partie représente les deux premiers groupes. La JCM s'est en effet enrichie de l'importante collection d'actinomycètes (*Streptomyces, Streptosporangium, Streptoverticillium, Micromonospora,* etc.) de la Kaken Pharmaceutical Co. Les champignons comprennent une importante collection de souches originales d'*Aspergillus* et de levures. Les informations sur les souches comprennent l'histoire de la souche, son statut, son origine, ses propriétés, ses milieux de culture, ses correspondants en d'autres collections, des références bibliographiques. Un index numérique complète ce catalogue.

CULTURE COLLECTION OF WOOD-INHABITING FUNGI, by Jean E. CLARK and Edson C. SETLIFF, 108 p., quarto, paperback, 1985. Forintek Canada Corporation, Western Laboratory, 6620 N.W. Marine Drive, Vancouver, B.C. V6T 1X2 or 800 Montreal Road, Ottawa, Ontario K1G 3Z5, Canada.

Forintek Canada Corporation, a non-profit forest research corporation, with laboratories in Ottawa and Vancouver, has amalgamated its two Culture Collections of wood-inhabiting fungi (Vancouver) and wood-inhabiting microorganisms (Ottawa) into one Collection with the present catalogue. "Although Fungal Culture Collections are often taken for granted, they do represent an important foundation stone upon which much of our forestry oriented microbiological work is based. Even so, our understanding of the fungi of importance to the forest industry has only just started. Biotechnological developments will bring about dramatic changes in microbiology and in society. Culture Collections represent the gene pool for tomorrow's research". That, from the catalogue preface, tells enough about the importance of such a fungus culture collection as a working potential as well as a repository. This

Collection maintains 1,960 cultures, mostly of Basidiomycetes, Ascomycetes and Deuteromycetes and some Phycomycetes from forest trees, from wood, and from wood products in Canada.

PARASITISCHE PILZE AN GEFÄSSPFLANZEN IN EUROPA, by Wolfgang BRANDENBURGER, xxii + 1248 p., 403 fig. on 150 tables, 17 x 24 cm, cloth hardcover, 1985. Publ. Gustav Fischer Verlag, Wollgrasweg 49 D-7000 Stuttgart, Germany. Price : DM 320.-

That voluminous book is a sylloge of all fungi on living vascular plants, recorded in Europe. In the first part, pathogenic fungus species are listed by host plant, disposed according to Melchior's plant systematics and by plant organ. They are described with diagnoses, symptoms and synonyms and refered to their taxonomical position. Related morphs are also described. The second part of the book is devoted to diagnoses and illustrations of the recorded fungus genera, disposed in taxonomical order. References to a selection of recent taxonomical literature are provided. The book ends with a glossary, a list of authors' names, an index of host plants and of fungi and with a bibliography. That book is an important contribution to European plant pathology. After Saccardo's Sylloge and Petrak's Index of Fungi, the book is the first to cover plant pathogenic fungi of entire Europe at once. It compiles many regional listings, like those of Jørstad, Moore, Pantidou, Parmasto, Viennot-Bourgin, Goidanich, Menzinger and others, and about 3,000 papers published before 1980. The book is conceived indeed to facilitate recognition by the plant pathologist of the pathogenic fungi on a particular host plant. It will also be of interest to the taxonomist, but only to a certain extent. The taxonomist might wish having the nomenclatural reference of the accepted fungus species names, the reference to the source of the proposed diagnoses and the inclusions,in the fungus names index, of the specific epithets in each genus with paginated reference to their hosts. Furthermore the author has not the pretention, when compiling fungus species, to solve inherent taxonomical or nomenclatural problems, which is the task of the taxonomist. The text is in German and edited to be as short as possible. In fungus descriptions the current use of abbreviated words implies a minimum knowledge of the language. Surely the book must stand in every plant pathology laboratory in Europe. It should be considered as a basis.

THE BRITISH ASCOMYCOTINA, AN ANNOTATED CHECKLIST, par P.F. CANNON, D.L. HAWKSWORTH and M.A. SHERWOOD-PIKE, CMI Publication, vii+302 p., 25 x 19 cm, relié toilé, 1985. Commonwealth Agricultural Bureaux, Farnham House, Slough SL2 3BN, UK. Price : US $ 100.- (£ 55.- membres du Commonwealth).

Cette liste des noms de genres (1300) et d'espèces (7300) d'Ascomycètes observés jusqu'à ce jour sur les Iles Britanniques est une révision des listes existantes des Pyrenomycètes (Bisby & Mason 1940), des Discomycètes (Ramsbotton & Balfour-Browne 1951) et des genres lichénisés (Hawksworth & al. 1980) et en Irlande (Muskett & Malone 1983). Elle est complétée encore par les relevés non publiés d'herbiers et de collections de cultures britanniques. La liste est alphabétique. La nomenclature des noms, mise à jour, donne la date de création du nom,

son classement, la synonymie principale, le substrat, l'anamorphe s'il y a lieu, et des références bibliographiques choisies. Une classification taxonomique suivant celle du Dictionary of the Fungi et un index des anamorphes sont proposés en fin d'ouvrage. Cet ouvrage s'avérera d'une grande utilité. Aussi, on devrait souhaiter le même type d'ouvrage pour les autres divisions des champignons et pour de plus grandes aires géographiques ?

WOOD PRESERVATION IN THE NETHERLANDS, by Niels BURGERS, Ron COCKCROFT and Dammes DE JONG, Swedish National Board for Technical Development Information 457, 72 p., 15 fig., 17 x 24 cm, paperback, 1985. Styrelsen för teknisk Utveckling, PO Box 43200, S-10072 Stockholm, Sweden.

This is the sixteenth booklet of a series of STU information, devoted to wood preservation through the world, and edited by Ron Cockcroft, the Secretary-General of the International Research Group on wood preservation. Wood preservation against fungi and insects is considered on technical points of view : methodology, products and legislation. Fourteen countries have contributed: Sweden, UK, Germany, Belgium, Japan, USA, Turkey, Thailand, Spain, Iran, Australia, Yugoslavia, Brazil and the Netherlands. A world list of wood preservative names has also been published.

BUTLLETI DE LA SOCIETAT CATALANA DE MICOLOGIA, n°7, 72 p., February 1983, n°8, 74 p., April 1984. 17 x 21 cm. Ed. Societat Catalana de Botanica, Facultat de Farmacia, Universitat de Barcelona, 08028 Barcelona, Spain.

FICHAS TÉCNICAS. Ia Serie, 1983 and IIa Serie, 1984. Ed. Societat Catalana de Micologia, ibidem.

These two publications relate the activities of Catalan mycologists. The Bulletin contains good papers on illustrated collecting records, keys and descriptions. Issue n°7 is devoted to the tenth anniversary of the Society. The Fichas Técnicas contain each twenty to thirthy descriptions of Basidiomycetes or Ascomycetes illustrated by line drawings of microscopic features.

AGARICA,MYKOLOGISK TIDSSKRIFT, a mycological journal published by the Mycological Society of Fredrikstad, n°10, 221 p., August 1984, n°11, 65 p., March 1985, 15x21 cm. Ed. Roy Kristiansen, P.O. Box 19, N-1652 Torp, Norway. Subsrciption NOK 25.- to 50.- depending on the number of pages. Two issues yearly.

Principally devoted to mushroom hunting datas, the journal also includes a number of good professional papers on Basidiomycetes and Ascomycetes.

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MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

Volume XXV April-June 1986 No. 2

CONTENTS

Nematoctonus and the tribe Resupinateae in Ontario, Canada. R. G. THORN and G. L. BARRON 321

New species **Dekkera custersiana** and **D. lambica**, teleomorphs of **Brettanomyces** ..... FWU-LING LEE and SHUNG-CHANG JONG 455

Studies in the genus **Phoma**. V. Concerning **Phoma pomorum**. JAMES F. WHITE and GARETH MORGAN-JONES 461

Studies in tropical Corticiaceae (Basidiomycetes) VI: A new species of **Steccherinum** from Brazil. KURT HJORTSTAM and VERA LUCIA RAMOS BONONI 467

Taxonomy of the **Fomitopsis rosea** complex (Aphyllophorales, Polyporaceae) ... J. CARRANZA-MORSE and R. L. GILBERTSON 469

Observation d'un **Taphrina** parasite sur **Polystichum setiferum** (Forskall) Moore ex Woynar en France .... ALAIN SCHNEIDER 487

Thyrea polyglossa and **Thyrea divergens** sp. nov. AINO HENSSEN 493

The genus **Arthroderma** and its later synonym **Nannizzia**. I. WEITZMAN, M. R. McGINNIS, A. A. PADHYE and L. AJELLO 505

A note on the typification of **Guignardia** ..... JOHN BISSETT 519

Valseutypella multicollis sp. nov. J. CHECA, G. MORENO and MARGARET E. BARR 523

Illinois fungi XII. Fungi and myxomycetes from wood and leaves submerged in southern Illinois swamps. C. A. SHEARER and J. L. CRANE 527

Some new and noteworthy fungi (Aphyllophorales, Basidiomycetes) from Iguazu, Argentina. KURT HJORTSTAM and LEIF RYVARDEN 539

Lasiosphaeriopsis stereocaulicola. O. ERIKSSON and R. SANTESSON 569

Biogeography of fungal ectoparasites of termites. MEREDITH BLACKWELL and WALTER ROSSI 581

Flavoparmelia, a new genus in the lichen family Parmeliaceae (Ascomycotina) ..... MASON E. HALE, Jr. 603

[CONTENTS continued overleaf]

ISSN 0093-4666 MYXNAE 25(2) 321-673 (1986)

Published quarterly by MYCOTAXON, Ltd., P.O. Box 264, Ithaca NY 14851
For subscription details, availability in microfilm and microfiche, and availability of articles as tear sheets, see back cover

[CONTENTS continued]

Russula vesicatoria and **Russula angustispora** sp. nov., two confusing species of **Russula** subsection **Lactarioideae.** GERALD F. BILLS 607

Acaulospora delicata sp. nov. – an endomycorrhizal fungus from Arizona. CHRISTOPHER WALKER, C. M. PFEIFFER and H. E. BLOSS 621

Botryohypoxylon gen. nov. and its anamorph, **Iledon** gen. nov. ..... GARY J. SAMUELS and JACK D. ROGERS 629

Notes on Hygrophoraceae IX: **Camarophyllopsis** Herink, an older name for **Hygrotrama** Sing. ..... EEF ARNOLDS 639

Ophiovalsa in the Pacific northwest. DEAN A. GLAWE and JON D. JENSEN 645

NOTICE: A change in editorial policy for long papers 657

Author INDEX 659

INDEX to fungous and lichen taxa 663

Errata 671

Reviewers 673

MYCOTAXON publication dates, volumes **24** and **25**(1) 673

[MYCOTAXON for January-March 1986 (**25**: 1-320) was issued February 19, 1986]

MYCOTAXON

Vol. XXV, No. 2, pp. 321-453 April-June 1986

NEMATOCTONUS AND THE TRIBE RESUPINATEAE IN ONTARIO, CANADA[1]

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ABSTRACT

Eight form-species of *Nematoctonus*, including 5 new species, were found in Ontario, and one extralimital species is described as new. Twelve of the 16 species recognised in *Nematoctonus* are described. In several cases, a single form-species includes the anamorphs of more than one teleomorph species. Eight species of *Nematoctonus* are not known to have teleomorphs. Twelve new teleomorph-anamorph connections are made. All teleomorphs occur in *Hohenbuehelia* (tribe Resupinateae), and all species of *Hohenbuehelia* treated have *Nematoctonus* anamorphs. The other genera of the Resupinateae were not nematophagous. Species of *Resupinatus* and *Stigmatolemma* lack *Nematoctonus* anamorphs, but have hyphal structures that suggest that they are parasitic. *Asterotus* and *Stromatocyphella* are unknown in culture. Twelve species of *Hohenbuehelia*, four of *Resupinatus*, and one in each of *Asterotus*, *Stigmatolemma* and *Stromatocyphella* occur, or are likely to occur, in Ontario. *Hohenbuehelia* is characterised by possession of hymenial metuloids and a *Nematoctonus* anamorph. In addition, fruit bodies of *Hohenbuehelia* have distinctive cystidia in the hymenium or on the surface of the pileus or stipe, which terminate in one or more hour-glass-shaped cells, each surrounded by a mucoid droplet.

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[1]Portion of a thesis submitted by the senior author to the University of Guelph in partial fulfillment of the requirements for the degree of Master of Science.

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These gloeosphex cystidia are unique among the agaric genera and resemble the capture organs of *Nematoctonus*. Species of *Resupinatus* lack metuloids, gloeosphex cystidia and *Nematoctonus* anamorphs, but possess diverticulate cheilocystidia and diverticulate cuticular hyphae, which are not found in *Hohenbuehelia*. The tribe Resupinateae should be classified in the Polyporaceae (= Pleurotaceae) to reflect the affinity of the Resupinateae with the genus *Pleurotus*. Parallel study of anamorphs and teleomorphs clarified the taxonomy of the Resupinateae at the generic and species levels. New species are: *Nematoctonus angustatus* Thorn & Barron, *N. brevisporus* Thorn & Barron, *N. cylindrosporus* Thorn & Barron, *N. geogenius* Thorn & Barron, *N. hamatus* Thorn & Barron, and *N. subreniformis* Thorn & Barron. New combinations are: *Hohenbuehelia atrocaerulea* (Fr.) Sing. var. *grisea* (Peck) Thorn & Barron, and *H. tremula* (Schaeffer: Fr.) Thorn & Barron.

INTRODUCTION

Species of *Nematoctonus* attack nematodes in soil or rotting wood. Drechsler (1941) described the genus to accommodate two species that differed from all other nematode-destroying fungi in that their hyphae had clamp connections. These fungi produce simple, hyaline conidia on short pegs along their hyphae. Nematodes are captured by adhesive processes formed on conidia or vegetative hyphae, and are then penetrated, colonized and digested. The adhesive trapping devices on hyphae of of predatory species of *Nematoctonus* have a secretory cell with a characteristic hour-glass shape, similar to the adhesive processes on germinated conidia of some of the endoparasites.

The outstanding feature of *Nematoctonus*, the presence of clamp connections, is characteristic of many heterokaryotic Basidiomycotina. Drechsler (1941) recognized the affinities of *Nematoctonus* to the Basidiomycotina and noted the similarity to cultures of *Corticium incrustans* (Nobles 1937), and *Pleurotus pinsitus*, as described by Vandendries (1934). The illustrations of *Pleurotus pinsitus* by Vandendries (1934) probably referred to *Hohenbuehelia geogenia* (Kuehner and Romagnesi, 1954). Unfortunately, Drechsler never observed a basidiome associated with any of his isolates of *Nematoctonus*.

Thirty-five years after Drechsler described *Nematoctonus*, a small agaric formed in a pure culture of an isolate of *Nematoctonus* (Barron and Dierkes, 1977). In the presence of nematodes, each discharged basidiospore germinated to produce a terminal adhesive process, with an

hour-glass secretory cell typical of *Nematoctonus*. This mushroom, a species of *Hohenbuehelia*, represented the first conclusive evidence of a sexual state in *Nematoctonus*. The apex of the cheilocystidia of their *Hohenbuehelia* was identical in appearance to the hour-glass adhesive knobs of *Nematoctonus* species, and Barron and Dierkes (1977) postulated that adhesive knobs may have evolved from such cystidia. Hour-glass secretory cells are common on the cystidia on the gills, the surface of the cap and stalk of many species of *Hohenbuehelia*. Kuehner et al. (1962) illustrated similar cystidia in *Hohenbuehelia longipes* and what appears to be the *Nematoctonus* state, complete with hour-glass adhesive trapping devices and conidia. Hoiland and Schumacher (1982) reported hour-glass secretory cells on the basal mycelium of *Hohenbuehelia panelloides* and presumed it to be nematophagous. The secretory cystidia in *Pleurotus* (Hilber 1982) differ slightly in that the apex is not as neat an hour-glass as those in *Hohenbuehelia*.

Thorn and Barron (1984) reported the nematophagous ability of some wood-inhabiting agarics. The cultures of six species of *Hohenbuehelia* (one misidentified as *Resupinatus silvanus*) and five species of *Pleurotus* attacked and consumed nematodes, and all six species of *Hohenbuehelia* that attacked nematodes had *Nematoctonus* anamorphs. Species of *Pleurotus* have a unique method of capturing nematodes (Thorn and Barron, 1984). Nematodes were immobilized following contact with toxic droplets on the hyphae. Hyphae in the vicinity of an immobilised nematode grew toward its mouth then down its oesophagus. Giuma and Cooke (1971) reported that nematodes were immobilised by contact with germinating conidia of *Nematoctonus haptocladus* and *N. concurrens* or by the extracts of the mycelia or culture filtrates. The toxin involved is thermostable and probably polysaccharide in nature (Giuma et al., 1973). This toxin differs substantially from the toxin of *Pleurotus* in that effects were noted after 24 hours (Giuma and Cooke, 1971) or 56 hours (Giuma et al., 1973), whereas the toxin of *Pleurotus* acted within one minute (Barron and Thorn, unpublished data). The *Pleurotus* toxin has not been characterized.

It is important to make the connection between species of *Hohenbuehelia* and their *Nematoctonus* asexual states. Nine species of *Nematoctonus* have been validly described (Giuma and Cooke, 1972), and occur in soils worldwide (Feder, 1962; Gazzano, 1973; Gray, 1983; Kitz and Embree, 1979; McCulloch, 1977). Barron (1978) reported five named and one unknown species of *Nematoctonus* from Ontario. *Hohenbuehelia* is

classified by Singer (1975) in the tribe Resupinateae, along with the genera *Aphyllotus*, *Asterotus*, *Resupinatus*, *Stigmatolemma* and *Stromatocyphella*. No monograph indicates how many species of the Resupinateae might occur in Ontario, but Coker (1921, 1944) reported 17 species from North Carolina.

This paper reports an investigation of the Ontario species of *Nematoctonus* and the fungi belonging to the Resupinateae that might represent their teleomorphs. This study consisted of two parts. Part one is a study of *Nematoctonus*. A survey was conducted to isolate *Nematoctonus* from varied habitats across Ontario and to collect fruit bodies and make cultures of any members of the Resupinateae encountered. Part two is a taxonomic study of the Ontario species of Resupinateae.

PART I: *NEMATOCTONUS*

When Drechsler (1941) described *Nematoctonus*, he emphasised just three things: species of *Nematoctonus* develop within minute living animals, have hyaline hyphae with clamp connections, and produce simple conidia on sterigmata along their hyphae. The conidia of *N. leiosporus* and *N. tylosporus* germinate to produce an adhesive process that adheres to the cuticle of nematodes (Drechsler, 1941). Fungi that attack nematodes by adhesive or ingested spores are termed parasites (Drechsler, 1941) or endoparasites (Barron, 1977). *Nematoctonus leptosporus* and *N. pachysporus* (Drechsler, 1943) are also endoparasitic. The six other described species of *Nematoctonus*, *N. haptocladus* Drechsler, 1946), *N. concurrens* (Drechsler, 1949), *N. campylosporus* (Drechsler, 1954), *N. robustus* (Jones, 1964), *N. lignicola* (Salonen and Ruokola, 1968; not validly published), and *N. tripolitanius* (Giuma and Cooke, 1972), produce adhesive trapping devices, sometimes called capture pegs or adhesive knobs, directly on their hyphae so that a number of nematodes can be caught by a single hyphal system. Fungi that capture nematodes in this way are termed predatory, or predaceous (Drechsler, 1941; Barron, 1977).

Giuma and Cooke (1972) provided a key to the nine validly-published species that emphasised the presence or absence of chlamydospores (= resting spores, or aleuriospores in this case), the presence or absence of predatory adhesive knobs on the hyphae, and the size and shape of the conidia. Two additional new species have since been described under provisional names (Alger, 1980). Surveys of nematophagous fungi by Barron (1978), Kitz and Embree (1979) and Gray (1983) each reported an unidentified

species of *Nematoctonus*. Our preliminary investigations (Thorn and Barron, 1984, and this study) revealed a number of *Nematoctonus* isolates that did not correspond with the descriptions of known species.

Barron (1978) surveyed the nematophagous fungi in 500 soil samples from Ontario, and recorded *Nematoctonus campylosporus*, *N. concurrens*, *N. haptocladus*, *N. leiosporus*, *N. pachysporus*, and one unidentified species of *Nematoctonus*. This survey, however, did not sample all habitats occupied by species of *Hohenbuehelia* and *Resupinatus* in Ontario, and provided no descriptions of the species reported.

MATERIALS AND METHODS[1]

A: Isolation Techniques

We attempted to isolate *Nematoctonus* from samples of soil, rotting wood, moss, or other substrates that were collected in a variety of habitats and locations in Ontario (Table 1). A total of 713 samples of 400-500 mL were collected and processed during the spring, summer and fall of 1983 and 1984. Most samples were processed by both the Baermann funnel technique (Giuma and Cooke, 1972) and the centrifuge technique (Barron, 1977), and a few were processed as soil sprinkle plates (Barron, 1977). All of the species of *Nematoctonus* found in a survey of Ontario farm soils (Barron, 1978) were recovered by the combination of the Baermann funnel and centrifuge techniques.

The Baermann funnel technique used in this study was simplified from that described by Giuma and Cooke (1972) and Barron (1977). First, the samples were mixed roughly by shaking the collecting bags, and breaking up any large clumps. A subsample of 100 to 150 mL was wrapped in two layers of Kimwipe tissue, and set on a screen tray in the Baermann funnel apparatus (illustrated in Barron, 1977). Nematodes were collected approximately 12 and 24 hours after setting up the funnels and transferred in 0.5 mL water to a petri plate containing approximately 10 mL of 2% water agar (WA). These WA plates, about a week old, were slightly dry and quickly absorbed the drop of water containing the nematodes.

The centrifuge technique (Barron, 1977) was modified slightly. A subsample of approximately 150 mL, without stones, was placed in a 500 mL mason jar. Approximately 200 mL of distilled water was added and the mixture blended at

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[1]See Appendix 1: Media and Reagents

medium speed with one blade of an Iona hand mixer. Part of the slurry was passed through a 0.7 mm mesh nylon screen to fill a sterile 50 mL round-bottomed centrifuge tube and spun in a clinical centrifuge for 8 minutes at one quarter-speed to remove the heavier soil particles and large spores. Approximately 14-15 mL of the cloudy supernatant was decanted into a 15 mL conical centrifuge tube, spun one hour at full speed, and all but 0.5 mL of the clear supernatant pipetted off with a sterile pasteur pipette and discarded. The residue was stirred with the tip of the pipette then spread in three crossing lines on a one-week-old WA plate.

Two drops of concentrated, mixed nematode suspension from stock cultures of ***Rhabditis terricola*** Dujardin (from the University of Guelph) and ***Panagrellus redivivus*** (L.) Goodey (obtained from B. Nordbring-Hertz, University of Lund, Sweden) were added to each of the WA plates containing the centrifuge residue. Stock cultures of these nematodes were maintained at room temperature in petri plates of Nigon's agar (Barron, 1977). Nematode stock cultures were transferred every two weeks by swirling 1 mL of sterile saline in a stock plate and pouring one third into each of three one-week-old plates of Nigon's agar.

Soil sprinkle plates (Barron, 1977) were prepared by sprinkling approximately one mL of sample across a WA plate which had been baited with two drops of nematode suspension as above.

The Baermann samples and baited plates were examined periodically for three weeks using a dissecting microscope at 10X, with an intense light set at a low angle to facilitate finding nematodes infected with ***Nematoctonus***. Nematodes infected by species of ***Nematoctonus*** could usually be recognized under the dissecting microscope by the fine, wispy fertile hyphae, and then confirmed quickly under the compound microscope by the presence of clamp connections on these hyphae.

B: Cultural Studies

Pure cultures of ***Nematoctonus*** were isolated in the following way. Once the presence of ***Nematoctonus*** was established, the plate was searched for a freshly-infected nematode, with clamped hyphae just emerging from the body of the host. This nematode was transferred with a fine needle to a plate of potato dextrose agar (PDA) amended with 60 ppm chlorotetracycline ("aureomycin") and 2.5 ppm benomyl (PD+AB agar). The nematode was dragged gently through the agar with the needle, then the needle flamed and cooled, and the nematode transferred to a clean area of the plate.

In most instances, hyphae of the *Nematoctonus* grew quickly out of the transferred nematode onto the PD+AB agar. The aureomycin suppressed bacterial growth, and the benomyl suppressed most contaminant fungi such as *Penicillium* and *Aspergillus* (Edgington et al., 1971). A pure culture of the *Nematoctonus* could usually be obtained by a transfer from the margin of the colony radiating from the original infected nematode.

The procedures used for the isolation of *Nematoctonus* cultures from fruit bodies of *Hohenbuehelia* are outlined in Part II.

The ability of cultures to consume nematodes was tested using the technique of Thorn and Barron (1984). After a new colony on WA had attained a diameter of about 3 cm, 10 to 20 clean, active nematodes were added to the colony surface. Observations on interactions between nematodes and the test fungus were made immediately and at 15-minute intervals for the first hour, then hourly for the next 8-12 hours, and again after 24 hours. More nematodes were added daily to the cultures and observations continued for 7 days.

Morphological features of *Nematoctonus* cultures were studied using a similar technique. Cultures on WA were seeded with a few nematodes. After one or more days, when abundant adhesive knobs or adhesive conidia had formed, more nematodes were added. Clean nematodes representing different infection stages, from first capture to total colonisation with abundant reproduction on external hyphae, were transferred on minute chips of agar to microscope slides, fixed with acetic alcohol, and mounted in PVLG (Koske and Tessier, 1983).

C: Taxonomic Characters

Species of *Nematoctonus* possess few morphological features useful in identification. These features are their hyphae, spores and adhesive processes.

A colony of *Nematoctonus* consists of assimilative hyphae within the body of the host nematode, and fertile hyphae on the exterior. The diameter of the assimilative and fertile hyphae may be relatively consistent within a species. The conidiogenous pegs that subtend and produce conidia (sometimes called sterigmata or conidiogenous denticles) vary between species as to length, branching, and breadth at the base and apex, although they vary within isolates as well. The conidiogenous pegs of most *Nematoctonus* species are simple but those of *N. tylosporus* and *N. leptosporus* were reported to be branched once or twice (Drechsler, 1941, 1943). Specialized branches bearing

multiple conidia in *N. robustus* (Jones, 1964) and *N. lignicola* (Salonen and Ruokola, 1968) were observed in cultures grown on nutrient agar, on which conidiation and growth may be atypical. These reports may thus be disregarded for taxonomic purposes.

Fertile hyphae produce asexual spores of one or two types: smooth, thin-walled conidia of various shapes, and thick-walled aleuriospores (= resting spores or chlamydospores), which are elliptical or ovate and often spiny. The size and shape of the conidia are among the most important features for the identification of species of *Nematoctonus*. The presence or absence of aleuriospores provides clear-cut distinctions between species of *Nematoctonus*, since only *Nematoctonus tylosporus*, *N. pachysporus* and *N. tripolitanius* have aleuriospores. The final set of morphological characters used in the taxonomy of *Nematoctonus* refers to the adhesive processes by which nematodes are caught and consumed. Predatory species have adhesive knobs on their hyphae (predatory adhesive knobs) and, as mentioned above, may or may not readily produce adhesive knobs on their conidia. Hyphal adhesive knobs of all species are produced by hour-glass-shaped secretory cells, but may vary in their location (terminal, intercalary, or both). The conidial adhesive processes of most species of *Nematoctonus* develop from hour-glass-shaped secretory cells, but those of *N. leptosporus* and *N. tylosporus* develop from the morphologically undifferentiated tips of conidial germ tubes. The hour-glass cells of both conidial and hyphal adhesive knobs are sometimes quite characteristic of different species of *Nematoctonus*.

Cultural characters, such as those used in the identification of wood-rotting fungi (Nobles, 1965) were not employed in this study, nor were characters of physiology or biochemistry. The agar beneath different species of *Nematoctonus* is often discoloured red, brown or yellow, and these colours may reflect the production of antibiotics (Robbins et al., 1947) or other metabolites. This discolouration was a feature of strains as well as species, since different single-spore isolates of *Nematoctonus robustus* (isolate T-14) produced either no colour or deep red-brown colouration in the PDA on which they were grown.

Measurements are given in micrometres (μm), with figures in parentheses representing values occurring in less than 10% of the measurements made. Acronyms of culture collections and herbaria are those listed by Holmgren et al. (1981).

RESULTS AND DISCUSSION

A: THE ONTARIO *NEMATOCTONUS* SURVEY

A total of 713 samples from soil, rotting wood, moss, and other suitable nematode habitats yielded 49 isolates of *Nematoctonus*, representing 5 form-species (Table 1). *Nematoctonus leiosporus* (25 isolates) and *N. hamatus* (14 isolates) were most common. The best substrates for *Nematoctonus* were compost, with *Nematoctonus* isolated from 37.5% of the samples, followed by barnyard soil and dung (19.7%), sawmill wastes (15%), and rotting hardwoods (9.3%). Coniferous forest soil and duff, and mosses, lichens, and samples from bogs yielded no isolates of *Nematoctonus*.

The Baermann funnel technique yielded 29 isolates of *Nematoctonus*, the centrifuge technique 21 isolates, and soil sprinkling 5 isolates (Table 2). The Baermann funnel and centrifuge techniques were highly complementary, since only four isolates were duplicated by both techniques. Four of the five isolates of *Nematoctonus* found by soil sprinkling were not found by the Baermann funnel or centrifuge techniques. Thus, if time had been available for the routine use of the soil sprinkling technique, considerably more isolates of *Nematoctonus* might have been detected.

Three of the five form-species of *Nematoctonus*

Table 1. Substrates Sampled and *Nematoctonus* Species Recovered

Substrate (# Samples)	A*	B	C	D	E	Frequency**
Barnyard Soil & Dung (76)	1	1	12	1	0	19.7%
Other Agric. Soils (60)	0	0	4	0	0	6.7%
Turf & Meadows (58)	1	1	1	0	0	5.2%
Compost (8)	0	0	3	0	0	37.5%
Hardwood Forest Duff & Soil (137)	0	3	2	2	0	5.8%
Coniferous Forest Duff & Soil (74)	0	0	0	0	0	0%
Rotted Hardwood (140)	0	6	3	1	3	9.3%
Rotted Conifer (52)	0	1	0	0	0	1.9%
Sawmill Wastes (20)	1	2	0	0	0	15.0%
Mosses, Lichens & Bogs (67)	0	0	0	0	0	0%
Total (713)	3	14	25	4	3	7.0%

*A = *Nematoctonus geogenius*
B = *N. hamatus*
C = *N. leiosporus*
D = *N. robustus*
E = *N. subreniformis*

**Expressed as a per cent of recoveries per samples studied

Table 2. A Comparison of Techniques for Recovery of *Nematoctonus*

Species	Baermann Funnel	Centrifuge Technique	Soil Sprinkling	Total
N. geogenius	2	1	1	3*
N. hamatus	4	10	2	14
N. leiosporus	23	4	1	25
N. robustus	0	3	1	4
N. subreniformis	0	3	0	3
Total	29	21	5	50

*Some isolates recovered by more than one sampling technique

encountered during the survey are described as new. Four species of *Nematoctonus* reported to occur in Ontario (Barron, 1978) were not encountered during this survey, and we believe that the occurrence of *N. campylosporus*, *N. concurrens*, and *N. haptocladus* in Ontario is doubtful. The occurrence of the fourth species, *N. pachysporus*, is documented in reference cultures.

Nematoctonus angustatus (teleomorph *Hohenbuehelia angustata*) and *N. brevisporus* (teleomorphs *H. pinacearum* and *H. unguicularis*) were not recovered, despite the known occurrence of their teleomorphs in Ontario. A large number of samples of substrates suitable for these teleomorphs were studied in the hope of recovering their anamorphs, without success. *Nematoctonus angustatus* and *N. brevisporus* are predatory species, and the recovery of predators is more favoured by the soil sprinkling technique than the Baermann funnel or centrifuge techniques (Barron, 1977). Both species produce small conidia that should be readily recovered by the centrifuge technique, but studies of these species indicates that the bait nematodes used in this study are not their preferred hosts. Conidia of *N. brevisporus* failed to germinate to produce adhesive knobs in the presence of bait nematodes, and the conidia of *N. angustatus* that had produced adhesive knobs failed to adhere to and infect bait nematodes. In addtion, *N. angustatus* produced conidia sporadically and in small numbers, in culture on WA with nematodes.

This survey indicated preferred habitats for *Nematoctonus* in Ontario. More intensive surveys of these habitats, coupled with more intensive sampling and processing, will undoubtedly indicate *Nematoctonus* to be more frequent and widespread, and might also uncover additional species.

B: TAXONOMIC PART

NEMATOCTONUS (Drechsler, 1941: 779)

The original description of ***Nematoctonus*** was as follows, "Mycelium filamentous, hyaline; the assimilative hyphae more or less branched, developing within living animals; the nonassimilative hyphae developing outside of animals, mostly sparse, often prostrate, provided with clamp connections, at intervals producing hyaline conidia, together sometimes with slightly coloured spores, on simple or slightly branched ascending sterigmata" (Drechsler, 1941).

The original description distinguished ***Nematoctonus*** from all other genera of Hyphomycetes. ***Antromycopsis broussonetiae*** Pat. & Trab., the anamorph of ***Pleurotus cystidiosus*** (Pollack and Miller, 1976), is nematophagous (Thorn and Barron, 1984), but the conidia are black, and produced in slimy coremia, unlike those of ***Nematoctonus***.

Ten species of ***Nematoctonus*** have been described, but one, ***N. lignicola*** Salonen and Ruokola (1968), is not validly published since no type was designated. A key to the nine validly published species was provided by Giuma and Cooke (1972). Since then, two new species were described under provisional names (Alger, 1980). Several surveys of nematophagous fungi have reported one or more unidentified species of ***Nematoctonus***, without providing descriptions (Barron, 1978; Kitz and Embree, 1979; and Gray, 1983). A key to all known species of ***Nematoctonus***, including five new species, is provided.

The importance of observing and describing the morphology of ***Nematoctonus*** isolates on the basis of nematode culture on non-nutritive agar cannot be emphasised too strongly. On nutrient agar, characters such as the method of production of conidia and conidium shape differ considerably from these characters in nematode culture (Barron and Dierkes, 1977).

KEY TO FORM-SPECIES OF *NEMATOCTONUS*

1. Conidia simple, not transversely septate **2**
1. Conidia 2-celled, allantoid, 9.0-13.6 X 2.8-4.0 µm; presence of adhesive knobs and consumption of nematodes unknown ..... ***Nematoctonus lignicola*** **nom. invalid.** Salonen and Ruokola (1968)
   2. Adhesive knobs present on hyphae; predatory species **3**
   2. No adhesive knobs present on hyphae (check closely); endoparasitic species **13**

3. Aleuriospores present, 10–15 (17.5) X 7.5–10 µm; conidia large, 15–20 (25) X 5–7.5 µm .... *Nematoctonus tripolitanius* Giuma and Cooke (1972)
3. No aleuriospores present; conidia narrower **4**
    4. Adhesive knobs predominantly terminal; hour-glass cells 3.5–6.5 µm long **5**
    4. Adhesive knobs predominantly intercalary; hour-glass cells 6–14 µm long **7**
5. Conidia narrow; straight or strongly curved **6**
5. Conidia stout; slightly or strongly curved, 9–14 X 3–5 µm ..... *Nematoctonus subreniformis*
    6. Conidia straight or slightly curved, 11–18 X 3.3–4.5 µm ..... *Nematoctonus haptocladus*
    6. Conidia rarely straight, most quite curved; (9.3) 10.0–13 (14.7) X 2.5–4 µm .... *Nematoctonus campylosporus*
7. Conidia cylindric, majority distinctly curved, 7–15 (18.5) X 2.5–4 µm ..... *Nematoctonus robustus*
7. Conidia cylindric, elliptical, or tapering; straight or slightly curved **8**
    8. Many conidia over 13 um long; 10–24 X 3.2–5.6 µm **9**
    8. Majority of conidia under 13 um long; 7–14 X 1.7–5.0 µm **11**
9. Conidia fusoid **10**
9. Conidia cylindric, 10–23 X 3.3–5.6 µm (if conidia are consistently broader than 5 µm, see *N. tripolitanius*, above) ..... *Nematoctonus concurrens*
    10. Conidia often with a distinct hook at apex, 12–24 X 3.5–4.5 µm ..... *Nematoctonus hamatus*
    10. Conidia without an apical hook, (7.5) 10–18 X 2 µm ..... *Hohenbuehelia longipes* anamorph, cf. Kuehner et al. (1962)
11. Conidia cylindric, 7–11.5 X 2.1–4.0 µm; hour-glass cell of predatory adhesive knobs narrow, 8–11.5 X 2–3.2 µm ..... *Nematoctonus brevisporus*
11. Conidia not cylindric, or with broader hour-glass cell in adhesive knobs **12**
    12. Conidia narrowly fusoid, 7.8–13.5 X 1.5–2.6 µm, in rotting hardwood logs .... *Nematoctonus angustatus*
    12. Conidia elliptic, broadly fusoid or cylindric, 7.5–14.5 X 3–4.5 µm; apex often slightly curved; in rich soil, woody debris or peat ..... *Nematoctonus geogenius*
13. Aleuriospores present **14**
13. Aleuriospores absent **15**

14. Aleuriospores narrowly elliptic, 8-11 X (3.3) 4-4.5 µm; conidia 15.5-22 X 2.2-2.9 µm .... *Nematoctonus tylosporus* Drechsler (1941)
14. Aleuriospores broadly elliptic, 10-13 X 5.5-8.8 µm; conidia 12-19 X 4-5.5 µm .... *Nematoctonus pachysporus*

15. Conidia fusoid, with prominent hook at apex, 12-24 X 2.7-5.4 µm ..... *Nematoctonus hamatus*
15. Conidia without hooked apex **16**
16. Conidia rod-shaped, 21-28 X 1.7-2.2 µm; adhesive apex without hour-glass secretory cell ..... *Nematoctonus leptosporus*
16. Conidia broader, with distinct hour-glass cell in apical adhesive knob **17**

17. Conidia fusoid, 14-30 X 2.3-4.0 µm; hour-glass cell with subapical constriction, terminal bulge approximately spherical, 0.6-1.2 µm diam .... *Nematoctonus leiosporus*
17. Conidia shorter or more cylindric **18**
18. Conidia cylindric, 12-23.5 X 2.2-4.2 µm; in rotting logs (deciduous or coniferous) .... *Nematoctonus cylindrosporus*
18. Conidia elliptic, broadly fusoid or cylindric, 9-16 X 3-4.5 µm, apex often slightly curved, and germinating to form one or two bulges prior to hour-glass cell; in soil, woody debris, or peat .... *Nematoctonus geogenius* (if conidia are as above but 7.5-11 X 2.0-2.8 µm, see comments on N84-604 under *N. geogenius*)

SPECIES DESCRIPTIONS

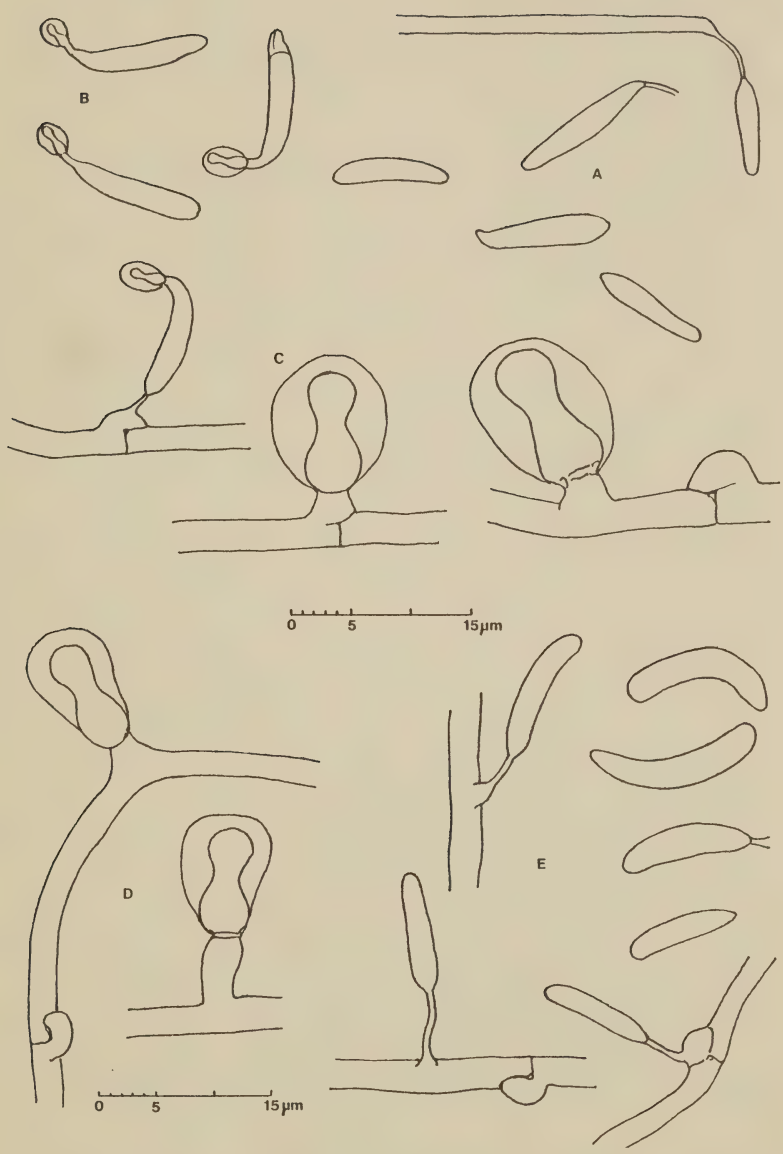
Nematoctonus angustatus Thorn et Barron, sp. nov. Fig. 1

Processus glutinosi hypharum vermiculos nematoideos adhaerentes; cellulae secretoriae 8-11 µm longae X 3-5 µm crassae, medio constrictae; mucus 9-12 X 6-8 µm. Conidia hyalina, laevia, plerumque anguste ovata, (7.8) 8.5-12 (12.5) X (1.7) 1.8-2.2 µm. Hyphae fibulatae, hyalinae; hyphae assumentes 2-3 µm crassae; hyphae extri 1.2-3.0 µm crassae. Typus DAOM #193369.

Assimilative Hyphae developing within living nematodes that are caught by adhesive knobs on external hyphae, and presumably also infecting by adhesive conidia, hyaline, with clamp connections, 1.8-3.0 µm diam., filling the body of the host and digesting its contents, then perforating the cuticle to emerge as external, fertile hyphae. **Fertile**

Hyphae hyaline, with clamp connections, 1.2–3.0 (3.5) µm diam., bearing numerous adhesive knobs and, in certain regions of the colony, conidia that are borne on thread-like stalks 0.8–6.0 µm long X 0.2–0.6 µm, sometimes inflated to 1.5 µm broad at the base, arising from the surfaces and apices of hyphae and from clamp connections. **Predatory Adhesive Knobs** predominantly intercalary on lateral branches up to 5 µm long X 3.5 µm diam., hour-glass cell at first small and naked, then growing and swelling to 8–11 X 3–5 µm, and becoming surrounded by adhesive mucus 8–14 X 5–11 µm, then capturing nematodes, which generally are first caught in the head region, and then become attached to one or more additional adhesive knobs in other body regions during thrashing attempts to escape, the hour-glass cells of the attached adhesive knobs then germinating to penetrate the cuticle of the nematode, and in addition several, often 10 or more, accessory adhesive branches home in on the head of the nematode from a distance of approximately 50 µm and can be seen entering the buccal cavity or penetrating the cuticle nearby. **Aleuriospores** none. **Conidia** hyaline, most tapering to the apex, straight or slightly curved, some narrowly cylindric, (7.8) 8.5–13 (13.5) X (1.5) 1.8–2.4 (2.6) µm, germinating to form an upturned germ tube tipped with an adhesive knob, the hour-glass cell 2.5–3.5 X 0.8–1.0 µm, usually surrounded by a mucoid droplet 3–4 X 2.5–3 µm.
Teleomorph: *Hohenbuehelia angustata* (Berk.) Singer.
Hosts: Adhesive conidia were never seen to infect nematodes in our mixture of *Rhabditis terricola* and *Panagrellus redivivus*, but the predatory adhesive knobs caught these nematodes readily and the nematodes were subsequently consumed. Although the substrate beneath fructifications of *Hohenbuehelia angustata* was sampled repeatedly, the anamorph was never isolated in Baermann, centrifuge, or sprinkle plates.
Habitat and Distribution: *Hohenbuehelia angustata* is found on soggy, brown-rotted hardwood logs in the eastern United States and Canada. It seems likely that the *Nematoctonus* state occurs in the wood as well.
Isolates Studied: *Hohenbuehelia angustata*: Blair, Ontario:

Figure 1 A–E: *Nematoctonus angustatus*, from cultures of *Hohenbuehelia angustata*. A–C: T-91 (RGT #830820/10). A) conidia; B) conidia germinated to form adhesive knobs; C) predatory adhesive knobs. D–E: T-87 (RGT #830822/10). D) predatory adhesive knobs (at a slightly reduced scale); E) conidia and fertile hyphae.


B
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15µm
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R.G. Thorn #840722/02 (= T-151) and RGT #840722/03 (= T-152); Pinery Provincial Park, Ontario: RGT #830822/10 (= T-87); Rondeau Provincial Park, Ontario: RGT #830812/01 (= T-80), RGT #830812/02 (= T-81), RGT #830820/05 (= T-88), RGT #830820/10 (= T-91, source of **type** specimen, DAOM #193369), and RGT #830820/08 (= T-92); Iowa, U.S.A.: R.L. Gilbertson #14724 (ARIZ; = T-72).

Observations: ***Nematoctonus angustatus*** is a distinctive form-species, readily recognised by its small, tapering conidia and the stout hour-glass cells in its adhesive knobs. The name ***angustatus*** (meaning "narrowing") is applicable both to its narrow, tapering conidia and to its known teleomorph, ***Hohenbuehelia angustata***.

The production of conidia is often minimal, and sporadic, in cultures on WA with added nematodes. These cultures produce many adhesive knobs and trap numerous nematodes, yet sometimes become senescent or overrun by the nematodes and associated bacteria without ever producing any conidia. Conidia, when they occur, are not produced in areas of most active nematode trapping. Instead, they are formed either in an area near the margin of the colony that is remote from the added nematodes, or in areas where many nematodes were trapped but the colony became overwhelmed by the buildup of associated bacteria. In the former case, the conidia tend to be shorter and broader than average, and generally do not germinate to produce adhesive knobs. Conidia produced in areas of great microbial activity germinate quickly to form an adhesive knob, but these were never seen attached to or infecting the bait nematodes.

It is not known whether this low and sporadic production of conidia occurs in nature. ***Hohenbuehelia angustata*** is the most common of our species of ***Hohenbuehelia***, and its fruit bodies are sometimes abundant in appropriate habitat at the right season. Fruit bodies of other species of ***Hohenbuehelia*** are rarely found, and those of several species, such as ***Hohenbuehelia cyphelliformis***, are minute and have only a few spore-bearing gills. It is possible that the large number of basidiospores produced by the ***H. angustata*** teleomorph compensates for the few conidia produced by ***N. angustatus***, and lessens the relative importance of these conidia in dispersal.

Small numbers of conidia in natural substrates, and host specificity, may have been factors contributing to the lack of recovery of ***N. angustatus*** during this study.

Nematoctonus brevisporus Thorn et Barron, sp. nov. Fig. 2

Processus glutinosi hypharum vermiculos nematoideos adhaerentes; cellulae secretoriae (7) 8–11 µm longae X 2.5–3.0 µm crassae, medio constrictae, 1.2–1.5 um crassae; mucus 9–12 X 6–9 µm; conidia hyalina, cylindracea, laevia, (8.2) 8.8–11.0 X (2.8) 3.0–3.8 (4.0) µm. Hyphae fibulatae, hyalinae; hyphae assumentes (1.5) 2–3 µm crassae; hyphae extri (1.5) 2–3.5 µm crassae. Typus DAOM #193368.

Assimilative Hyphae developing within living nematodes caught by adhesive knobs on the external hyphae, hyaline, with clamp connections, 1.5–3.0 (3.5) µm diam., filling the body of the host and digesting its contents, then penetrating the host's cuticle to emerge as external, fertile hyphae. **Fertile Hyphae** hyaline, with clamp connections, both aerial and prostrate, (1.2) 1.5–3 (4) µm diam., bearing conidia on tapering pegs 1–6 um long X 0.5–1.5 um broad at the base, 0.2–0.8 µm broad at the apex. **Predatory Adhesive Knobs** intercalary or occasionally terminal; the side branches on which the intercalary knobs are borne 3–12 µm long X 1.5–2.5 µm diam.; the hour-glass cells (7) 8–11.0 (11.5) X (2.0) 2.2–3.2 (3.8) µm. **Aleuriospores** none. **Conidia** hyaline, more or less cylindric, smooth, (7.0) 7.2–10.5 (11.5) X (2.1) 2.2–3.3 (4.0) µm, not observed to germinate to form adhesive knobs.

Teleomorphs: *Hohenbuehelia pinacearum* Thorn and *H. unguicularis* (Fr.) Miller.

Hosts: Some nematodes in the bait mixture of *Rhabditis terricola* and *Panagrellus redivivus* were captured and consumed, but whether one, or the other, or both species were consumed is not known. The consumption of nematodes on WA by the isolates studied did not keep up with the bait nematodes' reproduction, and the colonies were usually overrun about 7 days after the nematodes were added.

Habitat and Distribution: *Hohenbuehelia pinacearum* fruits on trunks and twigs of dead conifers, particularly *Abies*, in Europe and North America. *Hohenbuehelia unguicularis* occurs on logs and twigs of dead hardwoods, particularly *Populus*, and is likewise found in Europe and North America.

Isolates Studied: *Hohenbuehelia pinacearum*: Algonquin Provincial Park, Ontario: R.G. Thorn #831015/04 (= T-107). *Hohenbuehelia unguicularis*: Black Sturgeon Lake, Thunder Bay District, Ontario: DAOM #159734 (= T-47, source of type specimen, DAOM #193368); Cantley, Quebec, DAOM #191960; Star Lake, New York : DAOM #155519 (= T-100); France (det. R. Kuehner): CBS 606.79 (= T-184).

Observations: *Nematoctonus brevisporus* is readily distinguished from other members of the genus by its short,

cylindric conidia. These conidia were not seen to germinate to form adhesive knobs, even after prolonged association with nematodes and bacteria. In one plate of T-184, conidia germinated feebly 4 days after the colony had been overrun by nematodes. The germ tubes were cylindric, and soon ceased growth (Figure 2 C). The ability of *N. brevisporus* to infect nematodes endoparasitically remains unknown, but is nonetheless likely. It may be that neither of the bait nematodes used are the preferred hosts of *N. brevisporus*.

Hohenbuehelia pinacearum and *H. unguicularis* are both quite uncommon. *Nematoctonus brevisporus* was not recovered during this survey, despite repeated sampling of habitats suitable to its teleomorphs. This could be explained in part by the rarity of these fungi, and the possibility of host preference for species of nematodes other than those that were used as bait.

Nematoctonus campylosporus Drechsler (1954: 82) Fig. 3 A

Nematoctonus campylosporus was reported from Ontario (Barron, 1978), but not found during this study. An Ontario isolate (Barron #17, Fig. 3 B), previously identified as *N. campylosporus*, has been redetermined as *N. robustus*. The key features of *N. campylosporus*, according to the original description (Drechsler, 1954), are the slender hyphae 1.7-2.5 µm wide; small, terminal adhesive knobs with hour-glass cells 3.5-5 µm long by 1.6-2.0 µm wide; and strongly curved conidia 10-13 X 2.5-4 µm. The following description is based on two isolates from Argentina examined during this study:

Assimilative Hyphae hyaline, clamped, 1.5-2.5 µm diam. **Fertile Hyphae** hyaline, clamped, 0.8-1.8 µm diam., swelling to 2.5-3.0 µm diam. in the subapical segment, supporting the adhesive knobs. **Predatory Adhesive Knobs** predominantly terminal, occasionally intercalary; hour-glass cells 3.5-6.0 X 1.5-2.8 µm, surrounded by mucoid drop 4.5-7 X 3.5-5 µm. **Aleuriospores** none. **Conidia** hyaline, smooth, cylindric,

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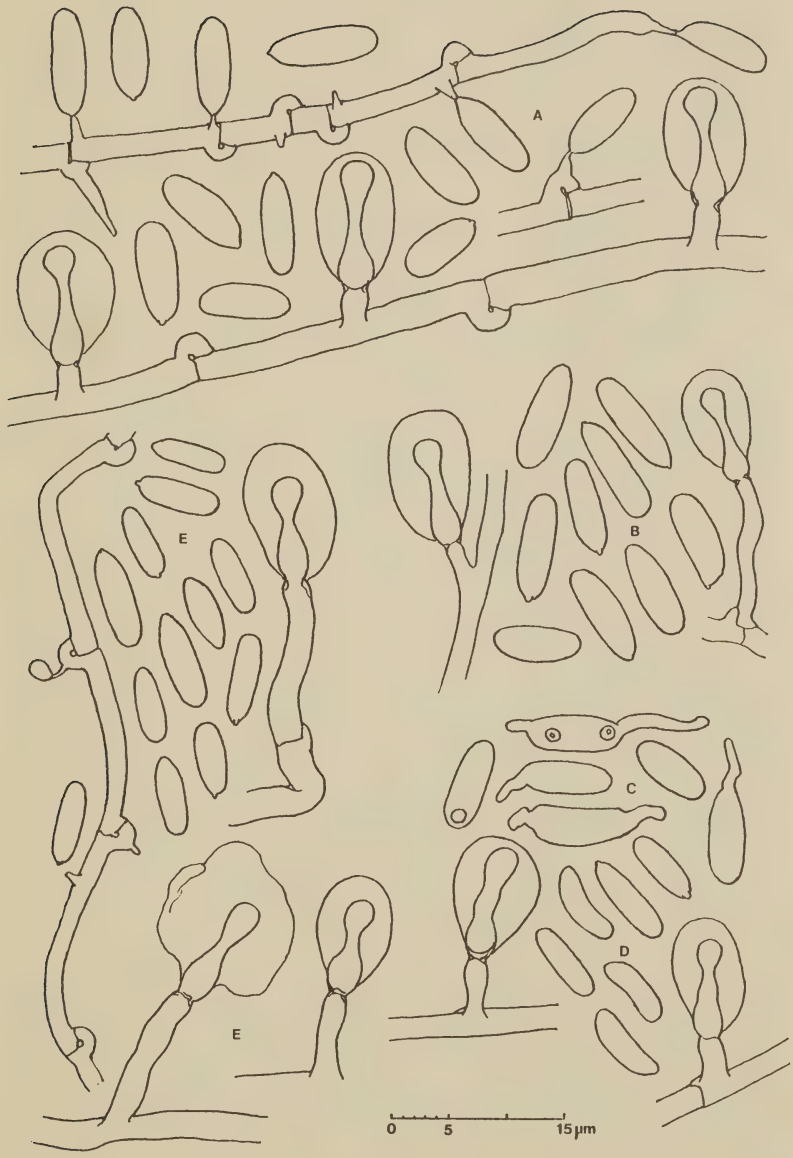
Figure 2 A-E: *Nematoctonus brevisporus* A) *Hohenbuehelia unguicularis*, T-47 (DAOM #159734), conidia, fertile hyphae and predatory adhesive knobs. B) *H. unguicularis*, T-100 (DAOM #155519), conidia and adhesive knobs. C-D) *H. unguicularis*, T184 (CBS 606.79). C) four germinated conidia, and two showing swelling prior to germination; D) conidia and predatory adhesive knobs. E) *Hohenbuehelia pinacearum*, T-107 (RGT #831015/04), conidia, fertile hypha and predatory adhesive knobs. Adhesive mucus of one adhesive knob spread and flattened in mounting.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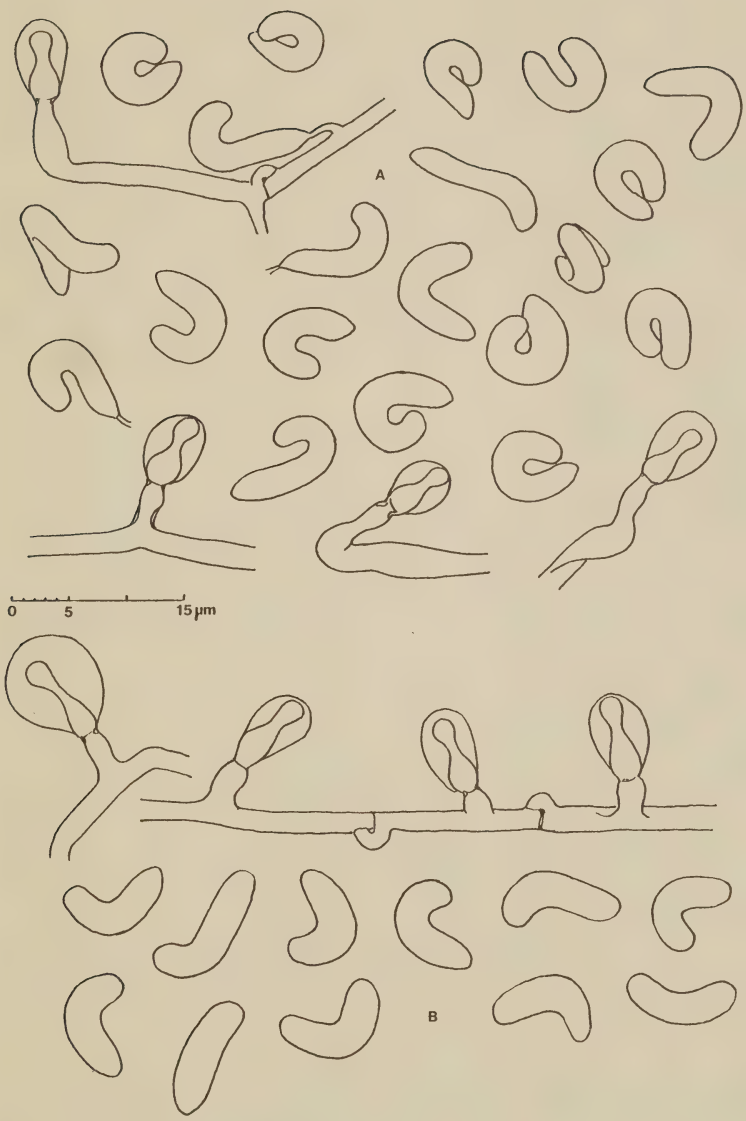
15 µm

strongly curved, 10–15 X 2.4–3.6 µm, with rounded apices and rounded or, more commonly, broadly conical bases.
Teleomorph: *Hohenbuehelia portegna* (Spegazzini) Singer.
Hosts: Both *Rhabditis terricola* and *Panagrellus redivivus* are readily consumed.
Habitat and Distribution: ***Nematoctonus campylosporus*** was originally described from rotting plant debris in a field in Louisiana, U.S.A., and has since been reported from agricultural soils in Queensland, Australia (McCulloch, 1977), and Missouri (Castaner and O'Leary, 1967; but the conidia are too long, 14–19 X 2.5–3.5 µm, averaging 16.3 X 3.1 µm). ***Hohenbuehelia portegna*** has been found on rotting dicot wood in the southern hemisphere.
Isolates Studied: *Hohenbuehelia portegna*: Sta. Catalina, Llavallol, Buenos Aires, Argentina, Nov. 3, 1968, J.E. Wright #1136 (BAFC #29143 = T-7). *Hohenbuehelia* sp.: Alto Parana, Missiones, Argentina, Mar. 10, 1980, M-3405 (BAFC #186 = T-8).
Observations: The key features emphasized by Drechsler (1954) still serve to distinguish this species. ***Nematoctonus campylosporus*** has small, predominantly terminal adhesive knobs; the fertile hyphae are generally narrow, but the penultimate segments of the hyphae supporting adhesive knobs are distinctly swollen; and the conidia are strongly curved (much more so, on average, than those of ***N. robustus***). Isolate B #17 represents ***N. robustus***, as it has large, intercalary adhesive knobs and less strongly curved conidia than ***N. campylosporus*** (Fig. 3 B). ***Nematoctonus robustus*** and ***N. campylosporus*** are, however, anamorphs of closely-related species of ***Hohenbuehelia***. Some intercalary adhesive knobs occurred in the isolates of ***N. campylosporus*** examined in this study. The vertical branches with multiple conidia, emphasized by Jones (1964) in the description of ***N. robustus***, are produced only in cultures on nutrient agar. If isolates are found that are intermediate in character between ***N. campylosporus*** and ***N. robustus***, it may be desirable to recognise only ***N. campylosporus***, and treat ***N. robustus*** as a synonym.

Figure 3 A: *Nematoctonus campylosporus*; **B**: *N. robustus*. A) *Hohenbuehelia portegna* (*N. campylosporus* state), T-7 (BAFC #29143), conidia, fertile hyphae, and predatory adhesive knobs. B) *N. robustus*, T-12 (Barron #17, as *N. campylosporus*), conidia and predatory adhesive knobs.


A
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15 µm
B

Nematoctonus concurrens Drechsler (1949: 382) Fig. 4 A

Nematoctonus concurrens was not found in Ontario during this study, but was reported to occur here by Barron (1978). A culture identified as *N. concurrens* (Barron #98 = T-21) represents an isolate of *N. robustus*, with curved conidia 11-14.4 X 3.2-4.0 µm, possibly the anamorph of *Hohenbuehelia cyphelliformis* (Fig. 4 B). The description of a British isolate follows:

Assimilative Hyphae hyaline, clamped, 1.8-3.2 µm diam. **Fertile Hyphae** hyaline, clamped, 1.5-2.5 µm diam. **Predatory Adhesive Knobs** intercalary on short side branches 3-8 X 2.2-3.0 µm, hour-glass cells 8.5-9.5 X 3.0-3.5 µm, adhesive mucus 9-11 X 5-6 µm. **Aleuriospores** none. **Conidia** hyaline, smooth, cylindric or narrowly elliptic, (14.8) 15.5-19 (21) X (4.2) 4.5-5.8 µm, the apices rounded, and the bases broadly conical.

Teleomorph: None known.

Hosts: *Rhabditis terricola* and *Panagrellus redivivus* were consumed readily.

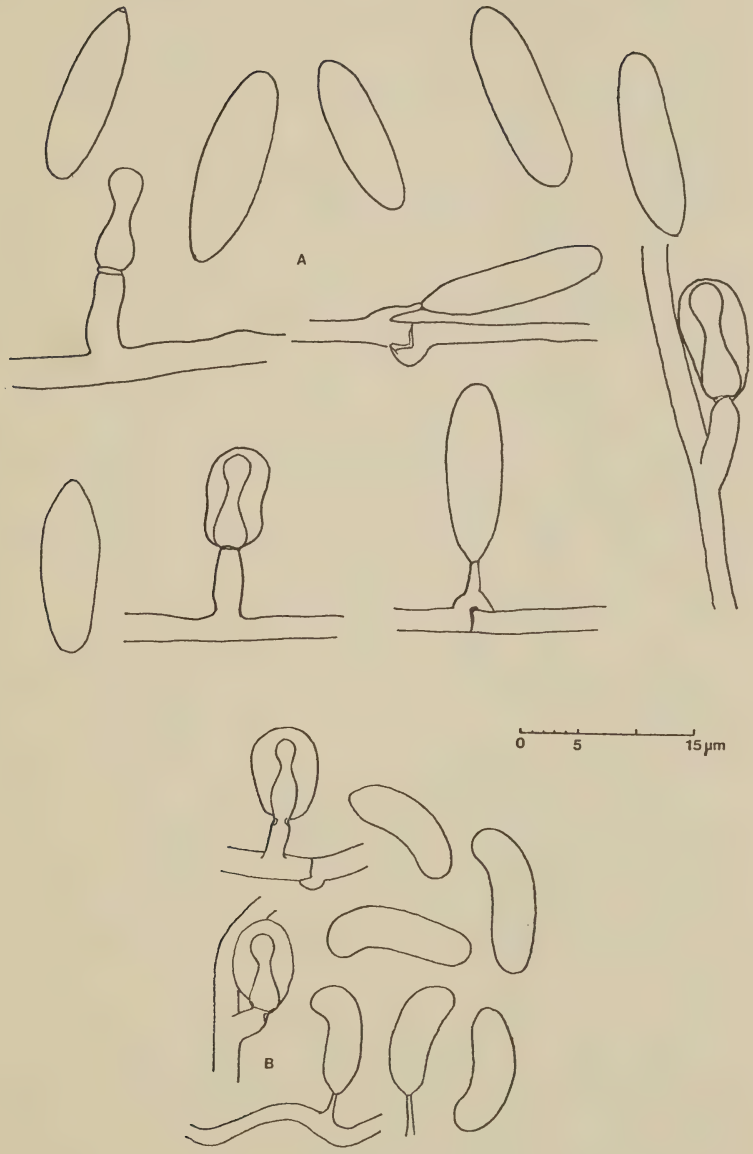
Habitat and Distribution: Originally described from decaying *Bromus secalinus* in Oregon, U.S.A. (Drechsler, 1949), *N. concurrens* has since been recorded in wood shavings from saunas in Finland (Ruokola and Salonen, 1967), from England, without habitat details (Giuma and Cooke, 1971), and from sheep or cattle-yard soils in New Zealand (Fowler, 1970). It may be significant that all of these records are from areas with maritime climates.

Isolate Studied: England: CBS #129.68 (= T-183), "capturing nematodes, R.C. Cooke".

Observations: The distinctive features of *N. concurrens* are its long, plump, straight conidia and long, intercalary adhesive knobs. R.C. Cooke's isolate of *N. concurrens* (Fig. 4 A) matched this concept perfectly, as do the descriptions and illustrations accompanying the records of this species by Ruokola and Salonen (1967), Fowler (1970), and Giuma and Cooke (1971).

It would be interesting to check the graminicolous species of *Hohenbuehelia*, such as *H. culmicola* Bon (1979), to determine if the anamorph of one or more of them might be *N. concurrens*.

Figure 4 A: *Nematoctonus concurrens*; **B**: *N. robustus*; A) *N. concurrens*, T-183 (CBS 129.68), conidia, fertile hyphae, and predatory adhesive knobs. B) *N. robustus* T-21 (Barron #98, as *N. concurrens*).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Nematoctonus cylindrosporus Thorn et Barron, sp. nov. Fig. 5

Species endoparasitica; processus glutinosi hypharum absentes. Hyphae assumentes hyalinae, fibulatae, 1.5-3.0 µm crassae. Hyphae extri procumbentes et ascendentes, hyalinae, fibulatae, sparsae, 1-2 µm crassae; hyphis ascentibus laxae. Conidia hyalina, laevia, cylindracea vel anguste elliptica, (10.5) 12-16 X 2.5-3.2 (3.8) µm, denique ex apice hypham germinationis corpus glutinosus formans; cellulae secretoriae 3.5-4.5 X 1.8-1.8 µm, medio constrictae; mucus 4-5 X 2.5-4 µm. Typus DAOM #193366.

Assimilative Hyphae developing within living nematodes infected by adhesive conidia, hyaline, with clamp connections, 1.5-3.5 (4.5) µm diam., filling the body of the host, then penetrating its cuticle to form external, fertile hyphae. **Fertile Hyphae** hyaline, clamped, 1.0-2.5 (3.5) µm diam., very sparse, both prostrate and ascending, with the ascendant hyphae quite lax, forming colonies 1-2 mm diam that produce more infectious conidia on simple pegs that often arise dorsally from clamps and are 0.5-4.0 um long X 0.5-2.0 µm broad at the base and 0.2-0.6 µm broad at the tips. **Predatory Adhesive Knobs** absent. **Aleuriospores** none. **Conidia** hyaline, smooth, cylindric or narrowly elliptic, (8.5) 11-18 (23.5) X (2.2) 2.5-3.5 (4.2) µm, germinating to form an adhesive knob either directly on the apex (or, more rarely, the base) of the conidium, or at the end of a tapering or slightly swollen germ tube; the hour-glass cell 2.7-4.0 X 1.2-1.8 µm; the adhesive mucus 3-5 X 2-4 µm. **Teleomorphs**: *Hohenbuehelia* stirps Petaloides sensu Singer and Kuthan (1980). All three isolates studied were identified by their senders as *H. petaloides*. Isolate T-2 is from a collection on *Abies* (OKM-2478-s, CFMR). Except for the habitat, and presence of metuloid cystidia on its cuticle, the specimen matches the description of *Geopetalum petaloides* sensu Kuehner and Romagnesi [1953 = *H. auriscalpium* (Maire) Singer]. The specimen from which isolate T-4 was derived was identified by R. Heim, whose concept of *H. petaloides* was probably the same as Kuehner's. Neither this specimen, nor the voucher of isolate T-82, were

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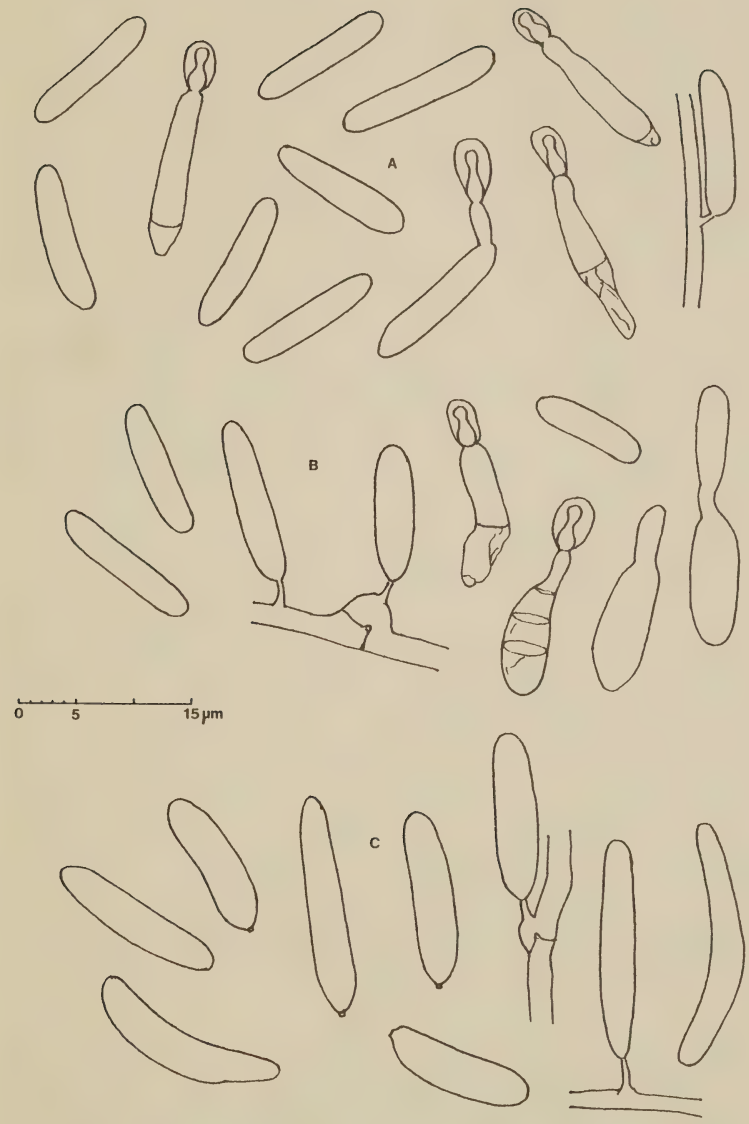
Figure 5 A-C: *Nematoctonus cylindrosporus* A) *Hohenbuehelia ?auriscalpium*, T-82 (CSAV #373; CBS 102.82). B) *H. ?auriscalpium*, T-4 (CBS 114.43), one germinated conidium is without cytoplasm except for hour-glass cell of adhesive knob, and two conidia at right have swollen and begun to germinate without forming adhesive knobs. C) *Hohenbuehelia* sp., T-2 (OKM 2478-S).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available for study.
Hosts: Isolate T-2 consumed nematodes of the *Rhabditis terricola-Panagrellus redivivus* bait mixture (but not vigourously), and had previously been found incapable of infecting *R. terricola* (Thorn and Barron, 1984). *Panagrellus redivivus* is a suitable, if not preferred, host for T-2. Isolate T-4 infects and consumes *R. terricola* (Thorn and Barron, 1984). Isolate T-82 was able to infect and consume either *Panagrellus redivivus* or *Rhabditis terricola*, but whether one, or the other, or both species, is uncertain.
Habitat and Distribution: The fruit bodies from which T-2 was isolated were collected on *Abies*, in Idaho, U.S.A. No information was available regarding the habitat of isolates T-4 (from France) or T-82 (from England). *Hohenbuehelia auriscalpium* is found on hardwood logs, often *Fagus*, but is known, as yet, only from Europe (Singer and Kuthan, 1980).
Isolates Studied: *Hohenbuehelia* sp.: McCall, Idaho, U.S.A., Aug. 30, 1964, O.K. Miller #2478-s (as *H. petaloides*, CFMR; = T-2); France: CBS 114.43 (Mycotheque de Paris #67, as *H. petaloides*; = T-4); Oxford, England, E. Jones, CBS 102.82 (as *H. petaloides*; = CSAV #373; = T-82; source of **type** specimen, DAOM #193366).
Observations: *Nematoctonus cylindrosporus* is distinctive among the obligate endoparasites by its long, cylindric conidia and lack of aleuriospores. The conidia of *N. cylindrosporus* are similar to those of *N. haptocladus* and *N. concurrens*, which are predatory species, forming predatory adhesive knobs, even in a colony originating from a nematode infected by a single conidium.

The *N. cylindrosporus* and *N. geogenius* anamorphs are helpful in the taxonomy of the *Hohenbuehelia "petaloides"* group, in which *H. auriscalpium* (*H. petaloides* sensu Kuehner and Romagnesi), *H. petalodes*, and *H. tremula* have been confused. *Nematoctonus cylindrosporus* is the anamorph of species of the group including *H. auriscalpium* (the "stirps Petaloides sensu stricto" of Singer and Kuthan, 1980), and is quite different from *N. geogenius*. Singer and Kuthan (1980) excluded terrigenous species of *Hohenbuehelia*, such as *H. petalodes* and *H. tremula*, the teleomorphs of *N.*

Figure 6 A-C: *Nematoctonus geogenius*. A) T-24 (Barron #184, as "N-1"), conidia, fertile hypha, and predatory adhesive knobs. B) *Hohenbuehelia petalodes* (det. Miller; *N. geogenius* state), T-130 (VT #1342), conidia, fertile hyphae and predatory adhesive knobs. C) *H. petalodes*, T-180 (BLT #411), conidia, fertile hyphae, and predatory adhesive knobs.

A
0
5
15 µm
B
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geogenius, from stirps Petaloides. The different anamorphs of these two groups support this taxonomic decision.

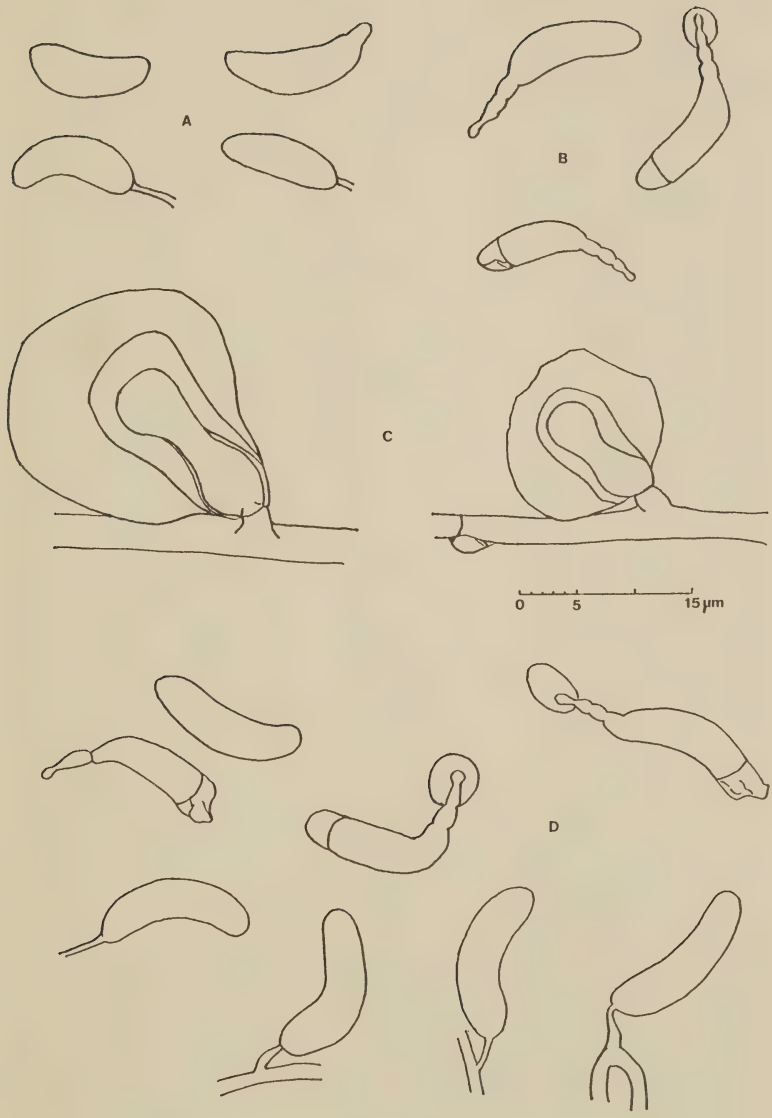
Neither *N. cylindrosporus* nor any of its teleomorphs have been found in Ontario.

Nematoctonus geogenius Thorn et Barron, sp. nov. Fig.s 6 & 7

Processus glutinosi hypharum vermiculos nematoideos adhaerentes (interdum rari vel ut videtur absentes); cellulae secretoriae 8-14 µm longae X 3.5-5 µm crassae, medio constrictae; mucus 9-15 X 7-12 µm. Conidia hyalina, elliptica vel fusoidea vel cylindrica, apicibus saepe flexa, 9.5-12.5 (13.0) X (3.2) 3.5-4.2 µm. Hyphae hyalinae, fibulatae. Typus DAOM #193365.

Assimilative Hyphae hyaline, with clamp connections, (1.0) 2.0-3.5 (5) µm diam., developing within living nematodes infected by adhesive conidia or caught by adhesive knobs produced on external hyphae. **Fertile Hyphae** growing externally from a colonized host, both prostrate and ascending, up to 1.5 mm long by (1.0) 1.5-3.5 (4.0) µm diam. (consistent at about 1.2 µm in some isolates but quite broad, or variable, in others), hyaline, beset with clamp connections and conidia produced on short, simple pegs 1-5 µm long X 0.5-1.5 µm broad at the base, tapering to 0.2-0.5 µm at the tip; the ascedant hyphae quite erect, not lax, the colony forming a white, hedgehog-like mound over the dead host. **Predatory Adhesive Knobs** abundant, infrequent, or lacking on colonies developing from individual nematodes, invariably formed when grown from pure culture onto WA with nematodes, predominantly intercalary on lateral branches 2-5 µm long X 2.5-4 µm broad; hour-glass cells 7-15 X 2-7 µm; adhesive mucus 7-17 (24) µm tall by 6-17 (24) µm diam. **Aleuriospores** none. **Conidia** hyaline, smooth, elliptic, somewhat fusoid, or cylindric, the apex often curved, (7.5) 8.5-12.5 (14.5) X (2.8) 3.0-4.2 (4.9) µm, germinating, sometimes while still attached to the parent hypha, to form one or, more commonly, two prominent bulges followed by an hour-glass secretory cell 3.0-4.0 (4.5) X 1.2-1.5 (1.8) µm, producing a mucoid droplet 2.5-3.5 µm diam.

Figure 7 A-D: *Nematoctonus geogenius*. A-C) *Hohenbuehelia tremula* (det. Semerdzieva as *H. rickenii*; *N. geogenius* state), T-83 (CSAV #374). A) Four conidia, one beginning to germinate; B) three germinated conidia with apical adhesive knobs and subapical bulges; C) two large predatory adhesive knobs. D) *N.* ?*geogenius* var., N84-604, conidia and fertile hyphae.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D

Teleomorphs: *Hohenbuehelia petalodes* (Bull.: Fr.) Schulz. and *H. tremula* (Schaeff.: Fr.) Thorn & Barron.
Hosts: Capable of attacking both *Panagrellus redivivus* and *Rhabditis terricola*, although these are clearly not the preferred hosts of some isolates.
Habitat: *Nematoctonus geogenius* and its teleomrphs occur in rich soils, including farmyards, in rotting woody debris, including old sawdust piles at an abandoned sawmill, and in well-rotted wood and peat in mossy coniferous forests.
Distribution: *Hohenbuehelia petalodes* is quite cosmopolitan in distribution, and *H. tremula* is found in both Europe and North America. Cultures of *N. geogenius* from Czechoslovakia, Sweden, Canada, the United States and Japan have been examined.
Isolates Studied: *Hohenbuehelia petalodes*: Falun, Sweden, Fungi Suecici #4656 (= T-104); U.S.A., VT #1342 (from O.K. Miller, Jr.; = T-130); Sacramento, California, U.S.A., B.L. Thompson #411 (HSC; = T-180, source of **type** specimen, DAOM #193365). *Hohenbuehelia petalodes* var.: Tottori, Japan, Sept. 2, 1981, E. Nagasawa s.n. (TOTTORI; = T-3). *Hohenbuehelia tremula*: Vysoký Chlumec, Czechoslovakia, Feb. 1979, CSAV #374 (= T-83); Lipon, Czechoslovakia, Sept. 1981, CSAV #375 (= T-84). *Nematoctonus geogenius* (anamorph only): near Guelph, Ontario: Barron #78 (as *Nematoctonus* #130; = T-19), Barron #145 (as *Nematoctonus* #20; = T-22), and Barron #184 (as *Nematoctonus* #1; = T-24); Whitefish Lake, Algonquin Provincial Park, Ontario: N84-589-1 (= T165). *Nematoctonus ?geogenius* var.: Denfield, Ontario, N84-604.
Observations: *Nematoctonus geogenius* is a distinctive, yet variable, form-species. The great range in size of adhesive knobs, for instance, is created by isolates that are at opposite ends of the range, yet other isolates overlap, and span the range in between. The most distinctive feature of this species is the shape of its conidia. They are usually slightly bent, especially at the tip, and, when germinated to form an adhesive knob, have one or two bulges prior to the hour-glass cell.

The two teleomorph species are similar to each other and presumed to be closely related (Kuehner and Romagnesi, 1953), and the shared anamorph form-species supports this view. The anamorph of *H. tremula* has slightly longer than average conidia (10-14.5 μm versus 8.5-11.5 in many), but one isolate of *N. geogenius* had conidia ranging from 7.5-13 μm in length. One culture of *H. tremula* (T-83) also had much larger predatory adhesive knobs than most cultures (hour-glass cells 12-15 X 4.5-7 μm), but another (T-84) had hour-glass cells as small as 8.5 X 4.5 μm, well within the size

range of other isolates of *N. geogenius*.

The fact that colonies of *N. geogenius* originating from nematodes infected by adhesive conidia often do not produce predatory adhesive knobs on their fertile hyphae can be quite misleading, especially if an isolate under study is not obtained in pure culture. Thus, two species from Nova Scotia, described as endoparasites under provisional names (Alger, 1980), are probably identical to *N. geogenius*. Both *Nematoctonus reniformis* (nom. prov.) and *N. bicatenulatus* (nom. prov.) were collected in farmyard soils, and have conidia very similar to those of *N. geogenius*, if somewhat longer (up to 16 µm long). Their conidia germinate in the same manner as those of *N. geogenius*, and the name *bicatenulatus* was chosen in reference to the two bulges adjacent to the hour-glass, identical to those in *N. geogenius*. Additional circumstantial evidence supporting our synonymy is the similar habitat of the three form-species, and the common occurrence (K.A. Harrison, pers. comm.) of *H. geogenia* (= *H. petalodes*) in Nova Scotia.

The name *geogenius* is derived both from the habitat, and the better-known name of one of the teleomorphs of this species.

One isolate from farmyard soil (N84-604), which was not successfully cultured, had conidia of a similar shape to those of *N. geogenius*, but narrower, (7.5) 9-11 X (2.0) 2.2-2.8 µm. It seemed to be restricted to a tiny, unidentified nematode in the Baermann sample, which may explain its narrower hyphae and smaller conidia. Predatory adhesive knobs were not seen. Its true identity remains uncertain, but it is closest to *N. geogenius*.

Nematoctonus hamatus Thorn et Barron, sp. nov. Fig.s 8 & 9

Processus glutinosi hypharum vermiculos nematoideos cellulae secretoriae 7.5-10 µm longae, 2.5-4 µm crassae, adhaerentes (interdum rari vel ut videtur absentes); medio constrictae; mucus 8-10 X 4.5-6.5 µm. Conidia hyalina, anguste ovata vel fusoidea, laevia, (13.5) 14-22 (24) X 3.2-4.2 (4.5) µm, mox hamata, denique ex apice hypham germinationis corpus glutinosus formans; cellulae secretoriae 3-5 X 1.2-1.8 µm, medio constrictae; mucus 4-6 X 2.5-5 µm. Hyphae hyalinae, fibulatae. Typus DAOM #193364.

Assimilative Hyphae developing within living nematodes infected by adhesive conidia or caught by adhesive knobs on external hyphae, hyaline, with clamp connections, 1.5-3.0 µm diam., filling the body of the host and digesting its contents, then perforating the cuticle to form external, fertile hyphae. **Fertile Hyphae** hyaline, clamped, 1.0-2.5

(3.7) µm diam., both prostrate and ascending, moderately dense, bushy, sparingly branched, up to 1.5 mm long; the ascendant hyphae often somewhat lax; producing conidia from simple, tapering pegs 0.5-6.6 µm long X 0.6-1.5 µm broad at the base, 0.3-0.5 µm broad at the tip; and also producing scattered, inconspicuous predatory adhesive knobs (often absent from colonies originating from single infected nematodes). **Predatory Adhesive Knobs** predominantly intercalary, on lateral branches 1-4 µm long X 2-3 µm broad, the hour-glass cells 7.5-10.5 X (2.0) 2.5-3.5 µm, surrounded by an ovoid mucoid ball 8-11 X 5-7 µm. **Aleuriospores** none. **Conidia** hyaline, fusoid, broadest at the base, tapering to the apex where there is often a slight to distinct hook, (9.5) 12.5-20 (24) X (2.7) 3.0-4.5 (5.4) µm, germinating to form an adhesive knob at the end of a short germ tube, or directly above the apical hook; hour-glass cells 3-5 (5.5) X 1.2-1.8 µm; adhesive mucus 4-6 X 2.5-5 (6) µm.
Teleomorph: *Hohenbuehelia mastrucata* (Fr.: Fr.) Singer.
Hosts: *Nematoctonus hamatus* readily attacks both *Panagrellus redivivus* and *Rhabditis terricola*.
Habitat: *Nematoctonus hamatus* was isolated from rotting wood and woody debris, primarily that of deciduous trees, but recorded once (N84-287) from heart-rot in *Pinus strobus*; from hardwood forest duff and soil; a lawn; and farmyard soil.
Distribution: *Nematoctonus hamatus* was found in Ontario and Quebec, but *Hohenbuehelia mastrucata* is widely distributed in the northern hemisphere.
Isolates Studied: *Hohenbuehelia mastrucata*: West Gate, Algonquin Provincial Park, Ontario, R.G. Thorn #820902/12 (= T-25); near Guelph, Ontario, Barron #167 (as *Nematoctonus* 289; = T-23, source of **type** specimen, DAOM #193364). *Nematoctonus hamatus* (anamorph only): near Guelph, Ontario, Barron #24 (as *Nematoctonus* #3; = T-16), and N83-27; Blair, Ontario, N82-C19 (= T-11); West Gate, Algonquin Park, N83-149 and N84-241; Whitefish Lake, Algonquin Park, N84-224 (= T-136) and N84-589-2 (= T-166); Barron Canyon Trail,

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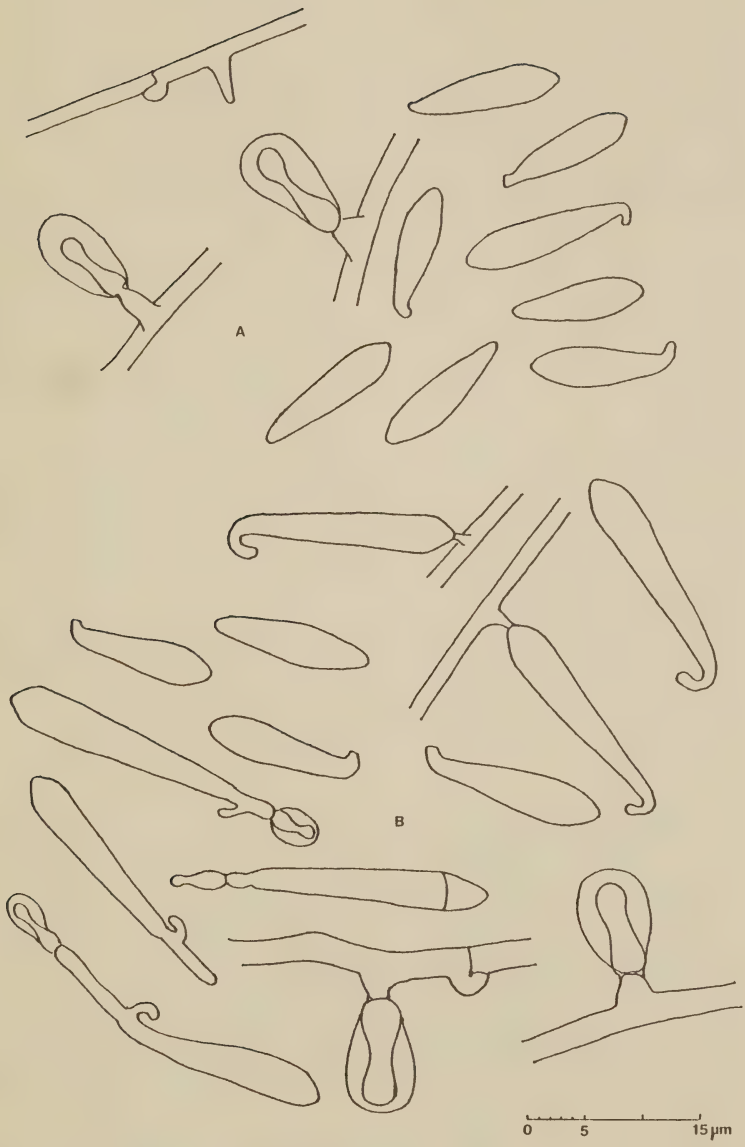
Figure 8 A-B: *Nematoctonus hamatus* A) T-166 (N84-589-2), conidia, hypha with conidiogenous peg, and predatory adhesive knobs. B) T-23 (Barron #167, "N-289") conidia, some germinating to form adhesive knobs, fertile hyphae, and predatory adhesive knobs. Long conidia were formed in colonies originating from single infected nematodes; short conidia from extensive colonies capturing nematodes with predatory adhesive knobs.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Algonquin Park N84-287 (= T-143); Renfrew, Ontario, N84-409 (= T-149); Dundas, Ontario, N84-E47 (= T-167); Cantley, Quebec, N84-575.

Observations: *Nematoctonus hamatus* is distinguished from all species of *Nematoctonus* by the hooked apices of its conidia. *Nematoctonus hamatus* is predatory, and has adhesive knobs on its hyphae, but is also a vigourous endoparasite, and adhesive knobs may be few or inconspicuous on colonies originating from nematodes infected by adhesive conidia. Isolates N-289 and T-25, and many others, were originally regarded as obligate endoparasites, distinct from those isolates that had predatory adhesive knobs. Continued observations of these cultures showed that they too had predatory knobs, although they are often absent, and, even when present can be few and inconspicuous.

Conidia from colonies originating on single nematodes average longer than those from predatory colonies.

Nematoctonus haptocladus Drechsler (1946: 19)

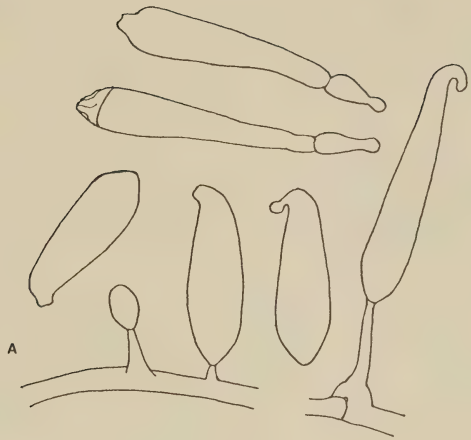
The key features of *N. haptocladus* are its small, predominantly terminal adhesive knobs with hourglass cells 3.5-5.5 X 2-3 µm, and cylindric, straight or very slightly curved conidia 11-18 X 3.3-4.5 µm (Drechsler, 1946). *Nematoctonus haptocladus* was not found during this study, and no cultures at Guelph were referrable to this species. A culture identified as *N. haptocladus* by Barron (ATTC #22119, = T-61) is *N. pachysporus*. Some isolates of *N. robustus* with conidia that are not strongly curved resemble *N. haptocladus*, but differ in their larger, intercalary predatory adhesive knobs. No teleomorph is known.

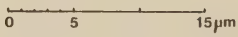
Nematoctonus leiosporus Drechsler (1941: 779) Fig. 10

The key features of *N. leiosporus* are lack of hyphal adhesive knobs and thus its obligately endoparasitic habit, and its long, fusoid conidia 20-27 X 2.6-3.4 µm, which germinate to form an hourglass-shaped secretory cell that produces and apical adhesive knob. The following description is based on isolates examined during this study:

Assimilative Hyphae hyaline, clamped, 1.0-2.5 µm diam. **Fertile Hyphae** hyaline, clamped, 1.0-2.0 (2.5) µm diam., producing conidia on slender, tapering denticles up to 5 um long X 2 µm at the base and 0.6 µm at the apex. **Predatory**

Figure 9 A-B: *Nematoctonus hamatus* A) T-16 (N82-C19), conidia, showing apical crook, and fertile hyphae. B) N84-575, conidia and fertile hyphae.


A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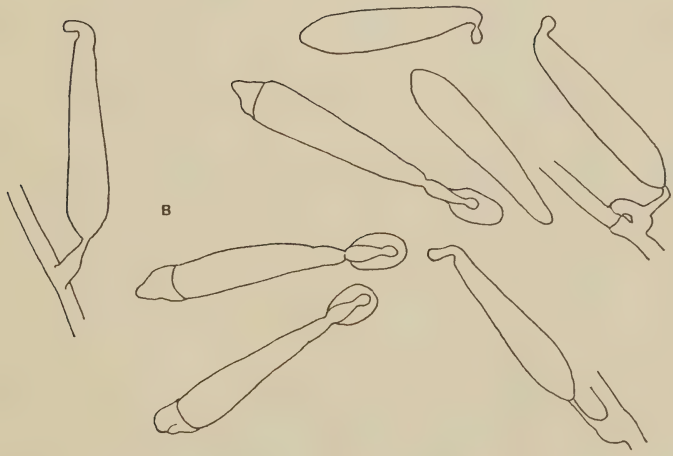
B

Adhesive Knobs none. **Aleuriospores** none. **Conidia** hyaline, narrowly fusoid, smooth, (14) 17.5-27 (30.5) X (2.1) 2.2-4.0 (4.2) µm, germinating to form a bent, tapering germ tube that forms an adhesive knob elevated above the substrate by 5-10 µm, the hour-glass 3-4.5 (5.5) X (0.9) 1.2-2.0 µm, with a subapical constriction, and approximately spherical final bulge, 0.6-1.2 µm diam.; the adhesive mucus 3.5-5 (6) X 2.5-4.0 (5) µm.
Teleomorph: None known.
Hosts: *Nematoctonus leiosporus* attacks both *Rhabditis terricola* and *Panagrellus redivivus* readily. The preferred host of many isolates, however, may be different, since *N. leiosporus* is most commonly recovered by the Baermann funnel technique.
Habitat: This species was originally described from hardwood forest duff (Drechsler, 1941), and has since been found to be of widespread occurrence in both woodland and agricultural soils, and in wood of saunas (Ruokola and Salonen, 1967). The best substrates for *N. leiosporus* appear to be compost and farmyard soils (Table 1).
Distribution: *Nematoctonus leiosporus* was originally described from Wisconsin (Drechsler, 1941), and has since been reported from California (Mankau and Clark, 1959), Iowa (Kitz and Embree, 1979), Ontario (Barron, 1978), Nova Scotia (Alger, 1980) England (Duddington, 1954), Ireland (Gray, 1983), Finland (Ruokola and Salonen, 1967), Uruguay (Gazzano, 1973; but with short spores), New Zealand (Fowler, 1970), and Queensland (McCulloch, 1977). It is clearly of world-wide distribution, and is the species found most commonly in surveys of nematophagous fungi. Isolates examined in this study extend the known distribution to Quebec, Alaska, and Hungary.
Isolates Studied: Pinetree Portage, Algonquin Provincial Park, Ontario, N84-193 (= T-135); Arkell, Ontario, N83-29 and N83-32; Desbarats, Ontario, N84-509 (= T-161); Douglas, Ontario, N84-407 (= T-150); Eramosa, Ontario, N84-373 (= T-147); Guelph, Ontario, N83-18, N84-54, N84-393, and N84-608; Hespeler, Ontario, N84-361 (= T-146); London, Ontario, N84-

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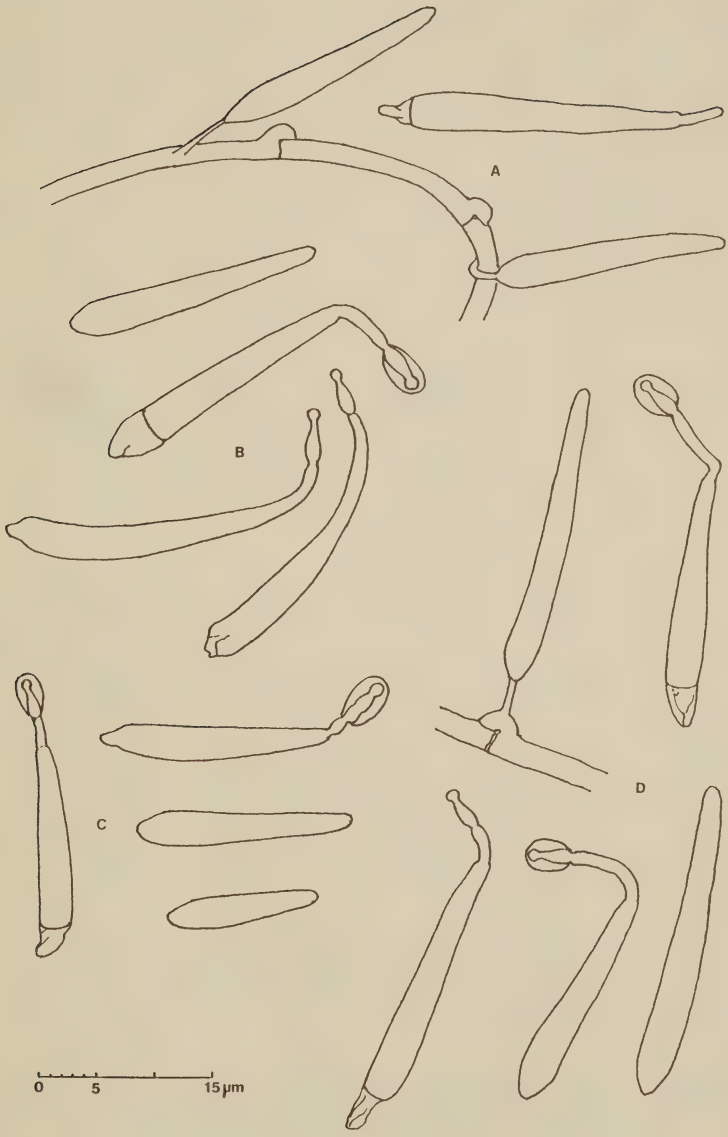
Figure 10 A-D: *Nematoctonus leiosporus*. A) T-150 (N84-407). B) T-134 (N84-93), with several conidia germinated to form adhesive knobs. The apical bulge of hour-glass is nearly spherical. C) T-111 (N83-173), one conidium with a three-lobed secretory cell. Conidia of this isolate were shorter than average. D) T-113 (AL #2), showing conidia that are slightly longer than average for *N. leiosporus*.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376 (= T-148); Morriston, Ontario, N83-173 (T-111); Preston, Ontario, N83-107 (= T-58), N83-112,, N84-356 (T-145), N84-359, and N84-613; Renfrew, Ontario, N84-411; Rondeau Provincial Park, Ontario, N84-475 (= T-155); Turkey Point, Ontario, N84-93 (= T-134); Cantley, Quebec, N84-583 (= T-163); Alaska, U.S.A., AL#2 (from E.C. Bernard, University of Tennesse; = T-113); Acsád, Hungary, N84-492 (T-153); Vertés, Hungary, N84-498 (= T154).

Observations: ***Nematoctonus leiosporus*** is a distinctive, but somewhat variable, form-species. The key features are its long, fusoid conidia without a hook at the apex, its endoparasitic habit, the lack of aleuriospores, and its conidial hour-glass cells which are subapically constricted and have a nearly spherical terminal bulge. Some isolates have consistently shorter, or longer, conidia, but others have conidia with overlapping size ranges, so there appears to be no valid cause for subdividing this species.

Nematoctonus leiosporus is probably a holomorphic anamorph, having evolved away from an ancestral ***Hohenbuehelia*** teleomorph in favour of specialization as a nematophagous endoparasite.

Nematoctonus leptosporus Drechsler (1943: 188)

The key features of ***N. leptosporus*** are its obligately endoparasitic habit, and long, extremely narrow conidia 21-28 X 1.7-2.2 µm, which germinate to form an apical adhesive knob that lacks an hourglass-shaped secretory cell or abundant mucus (Drechsler, 1943). Seven loose conidia measuring 18-24 X 1.6-1.9 µm were found in a slide of infected nematodes from a centrifuge plate of sample 84-243. These conidia were probably present in the centrifuge sediment, without having infected the bait nematodes, which were heavily infected by ***N. subreniformis***. The occurrence of ***N. leptosporus*** in Ontario remains to be confirmed.

Nematoctonus pachysporus Drechsler (1943: 185) Fig. 11

The distinctive features of ***N. pachysporus*** are the presence of ovoid, yellowish, warty or echinulate resting spores (aleuriospores) that are 10-13 X 5.5-7.5 µm; narrowly

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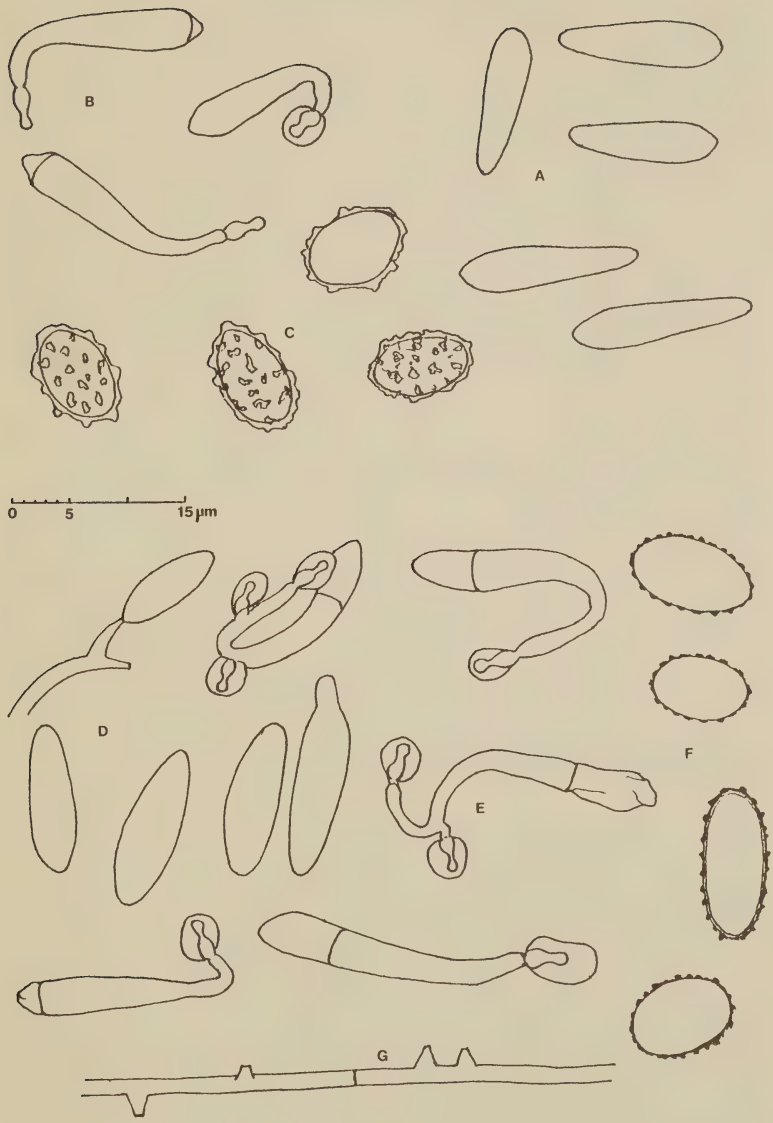
Figure 11 A-G: ***Nematoctonus pachysporus***. A-C) T-20 (Barron #93). A) conidia; B) germinated conidia with adhesive knobs; C) aleuriospores. D-G) ***Hohenbuehelia*** sp. (***N. pachysporus*** state), T-74 (Singer B12424). D) conidia; E) germinated conidia with adhesive knobs; F) aleuriospores; G) simple-septate fertile hypha with conidiogenous pegs.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ovate, smooth and hyaline conidia 12–19 X 4–5.5 µm; and the lack of hyphal adshesive knobs (Drechsler, 1943). The following description is based on isolates examined during this study:

Assimilative Hyphae 1.5–3.5 µm diam., hyaline, clamped, but simple-septate in T-74. **Fertile Hyphae** (1.0) 1.5–2.5 (3.0) µm diam., hyaline, clamped, but simple-septate in T-74. **Predatory Adhesive Knobs** absent. **Conidiogenous Pegs** simple, truncate-conical, 1–3 µm long, 1.5–2.0 µm broad at the base, 0.6–1.0 µm broad at the tip. **Aleuriospores** pale yellowish, finely to coarsely warted, ovate to subglobose, (8.5) 10–13 X (5.5) 6–8 µm. **Conidia** hyaline, fusiform, smooth, (13) 14–17.5 (19) X (3.0) 3.2–4.8 (5.2) µm, germinating to form a tapering germ tube tipped with an hour-glass secretory cell 3.5–4.5 X (1.2) 1.5–1.8 µm, which becomes surrounded by a mucoid droplet 3.5–7 X 2.8–4.0 µm; the germ tube often continuing to form one or two more adhesive knobs in a sympodial fashion.

Teleomorph: A fruit body of an undescribed species of *Hohenbuehelia* from Brazil (Singer, in press) sent by R. Singer, yielded a culture that is referrable to *Nematoctonus pachysporus*.

Habitat and Distribution: *Nematoctonus pachysporus* was originally isolated from nematode-infested tomato roots from Maryland, U.S.A. (Drechsler, 1943), and has since been reported from agricultural soils in England that were infested with potato or cereal root eelworms (Duddington, 1954), from cultivated areas in Queensland, Australia (McCulloch, 1977), and from Ontario soils (Barron, 1978). The species of *Hohenbuehelia* that yielded a *Nematoctonus pachysporus* anamorph was collected on dead dicot wood in the igapó vegetation zone of the Amazon basin in Brazil (Singer, 1984).

Isolates Studied: *Hohenbuehelia* sp.: Igarape do Tarumazinho, Amazonas, Brazil, Mar. 13, 1983, Singer B12424 (= T-74). *Nematoctonus pachysporus* (anamorph only): near Guelph, Ontario, Barron #25 (as *Nematoctonus* #2; = T-18), Barron #93 (as *Nematoctonus* sp.; = T-20) and ATTC #22119 (as *Nematoctonus haptocladus*, det. Barron; = T-61; and probably the same as either Barron #25 or Barron #93).

Observations: The endoparasitic habit, broad aleuriospores, and fusoid conidia, which often have more than one adhesive knob, make *N. pachysporus* a very distinctive form-species. Reports in the literature of *N. pachysporus* can be accepted with much more confidence than those of certain other species of *Nematoctonus*, such as *N. haptocladus*.

Culture T-74 was originally isolated as a

heterokaryotic culture with clamp connections from a gill fragment of a dried specimen of a new species of *Hohenbuehelia*. This culture evidently contained or produced a monokaryotic, clampless sector, which was subsequently selected accidentally during a transfer for routine culture maintenance. This monokaryotic isolate is interesting in several respects. It is still readily recognisable as *N. pachysporus*, and is still quite capable of infecting and consuming nematodes. The ability of monokaryons of *Nematoctonus* to infect nematodes has been noted by Barron and Dierkes (1977) and Kitz and Embree (1979). The monokaryotic isolate reported by Kitz and Embree (1979) was regarded as most similar to *N. pachysporus*, but did not produce aleuriospores, which isolate T-74 did. Kitz and Embree's isolate, from woodland soil, may possibly represent *N. hamatus*.

Nematoctonus robustus Jones (1964: 57) Figure 3B & 12

The key features of *N. robustus* are the curved, cylindric conidia (9.1) 9.3-17.0 (18.1) µm (along the curve) x 2.5-4 µm; and the large, intercalary hyphal adhesive knobs with hourglass-shaped secretory cells 7-10.5 X 2.5-3 µm (Jones, 1964). The following description is based on isolates examined during this study:

Assimilative Hyphae hyaline, clamped, (1.0) 1.5-3 (4) µm diam. **Fertile Hyphae** hyaline, clamped, (1.0) 1.5-3 (4) µm diam. **Predatory Adhesive Knobs** intercalary or rarely terminal, hour-glass cells (4.5) 6.5-9 (10) X (2.0) 2.2-3.2 (3.8) µm, becoming surrounded by mucoid balls (5) 7-10 (11) X (3.5) 5-7 (8) µm. **Aleuriospores** none. **Conidia** hyaline, smooth, cylindric, slightly or strongly curved, (7.5) 8.5-15 (18.5) X (2.1) 2.5-4.0 (4.5) µm.

Teleomorphs: *Hohenbuehelia approximans* (Peck) Singer, *H. cyphelliformis* (Berk.) Miller, *H. atrocaerulea* (Fr.) Singer var. *grisea* (Peck) Thorn & Barron, and a culture (T-132) sent by O.K. Miller, Jr. as *H. nigra* all yielded anamorphs referrable to *Nematoctonus robustus*.

Hosts: Both *Panagrellus redivivus* and *Rhabditis terricola* were readily consumed by all isolates.

Habitat: *Nematoctonus robustus* was described from forest leaf litter (Jones, 1964), but is also found in rotting wood, where its teleomorphs are known to occur, and soil. *Hohenbuehelia cyphelliformis* fruits near the ground on dead stems of woody perennials, but may make its way there from the soil, in order to gain a slight height advantage for the release of basidiospores.

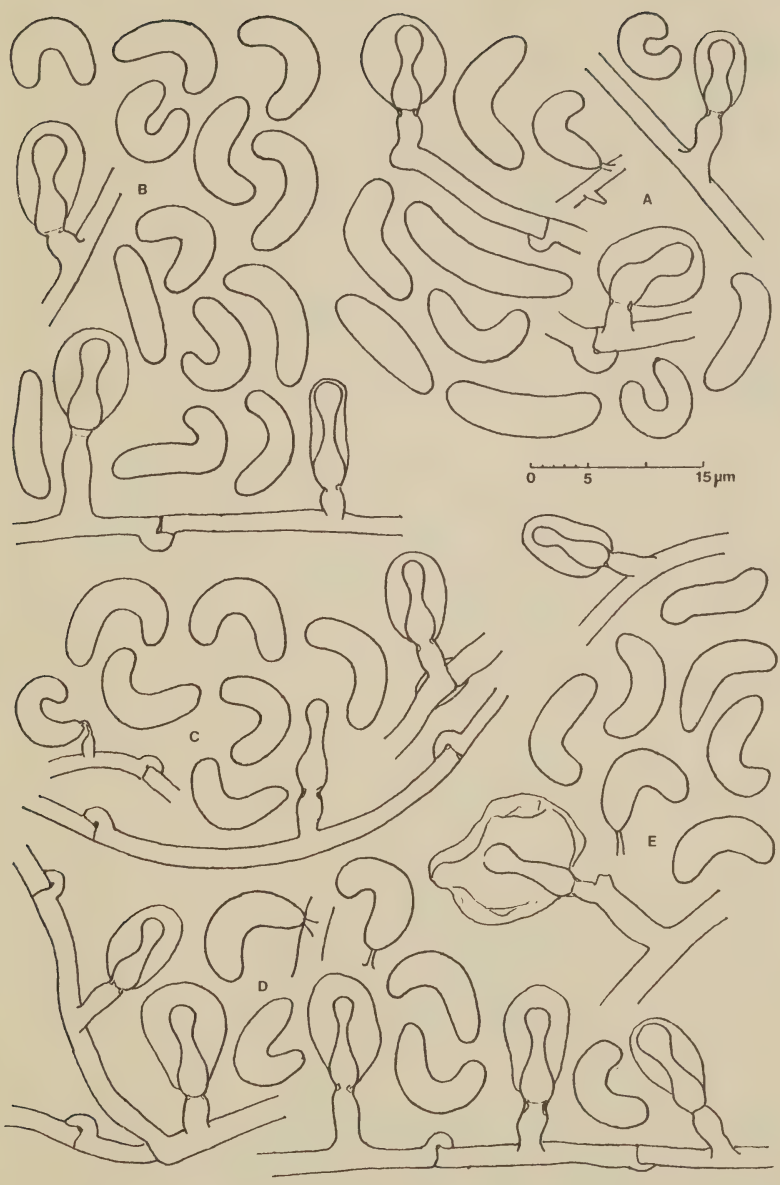
Distribution: *Nematoctonus robustus* was described from Ghana

(Jones, 1964), and has since been found in Iowa (Kitz and Embree, 1979), Nova Scotia (Alger, 1980), Finland (Salonen and Ruokola, 1968), New Zealand (Fowler, 1970), and Ontario (below). The report by Castaner and O'Leary (1967) of *N. campylosporus* from Missouri may represent this species, as the conidia were reported as 14–19 µm long. *Hohenbuehelia atrocaerulea* var. *grisea* is found world-wide. *Hohenbuehelia approximans* and *H. nigra* are, as yet, only known from the Americas.

Isolates Studied: *Hohenbuehelia approximans*: Eramosa, Ontario, R.G. Thorn #841117/01 (= T-176); Point Pelee National Park, Ontario, DAOM #188324 (= T-116); U.S.A., VT #1365 (from O.K. Miller, Jr.; = T-131). *Hohenbuehelia cyphelliformis*: Algonquin Provincial Park, Ontario, RGT #841013/01 (= T-171); Eramosa, Ontario RGT #841117/02 (= T-175). *Hohenbuehelia atrocaerulea* var. *grisea*: U.S.A., CBS #354.34 (= Overholts #2948; = T-5); Bell's Corners, Ontario, DAOM #48912 (= T-9); Cantley, Quebec, RGT #840909/02 (= T-177). *Hohenbuehelia nigra*: U.S.A., VT #1324 (from O.K. Miller, Jr.; = T-132). *Nematoctonus robustus* (anamorph only): Petawawa River, Algonquin Provincial Park, Ontario, N84-274 (= T-141) and N84-275 (= T-142); Douglas, Ontario, N84-404; near Guelph, Ontario, Barron #17 (as *Nematoctonus campylosporus*; = T12), Barron #20 (as *Nematoctonus* 90; = T-14), Barron #21 (as *Nematoctonus* sp.; = T-15), and Barron #98 (as *Nematoctonus concurrens*; = T-21); Cantley, Quebec, N84-579 (= T-162); U.S.A., ATTC #22525 ("J. Roxon, bark"; = T-62).

Observations: *Nematoctonus robustus* is an inclusive form-species that can be recognised by its slightly to strongly curved, cylindric conidia, its intercalary adhesive knobs that are longer than those of *N. campylosporus*, and its moderately thick hyphae. Some isolates with small, intercalary adhesive knobs are somewhat intermediate between *N. robustus* and *N. campylosporus*, and others, with most conidia only slightly curved, are intermediate between *N.*

Figure 12 A-E: *Nematoctonus robustus*. A) *Hohenbuehelia cyphelliformis* (*N. robustus* state), T-171 (RGT #841013/01), conidia, fertile hyphae and predatory adhesive knobs. B) T-62 (ATCC #22525). C) *Hohenbuehelia atrocaerulea* var. *grisea* (*N. robustus* state), T-162 (N84-579, from beneath fruiting bodies of RGT #840909/02, and identical to culture of that collection). D) *H. approximans* (*N. robustus* state), T-176 (RGT #841117/01). E) *H. nigra* (det. Miller; *N. robustus* state), T-132 (VT #1324).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robustus and *N. concurrens*. The shape of the conidia and the size of the adhesive knobs tend to vary considerably within isolates as well, and this variability might even be considered characteristic of *N. robustus*. The "average" character of variable isolates generally allow them to be identified clearly as *N. robustus*.

No consistent differences could be seen between the cultures of different teleomorphs, with the possible exception of cultures of *Hohenbuehelia cyphelliformis*. The conidia of *H. cyphelliformis* (Fig. 12 A) tend to be longer on average (12–18.5 X 3–4.2 µm) than those of other isolates, but the size ranges completely overlap. The teleomorphs of *N. robustus* form quite a natural grouping, ranging from *Hohenbuehelia atrocaerulea* var. *grisea* to *H. approximans* to *H. cyphelliformis* in one direction, and to *H. nigra* (possibly through *Hohenbuehelia mustaliensis*) in the other.

Nematoctonus subreniformis Thorn et Barron, sp. nov. Fig. 13

Processus glutinosi hypharum vermiculos nematoideos adhaerentes, plerumque termiales; cellulae secretoriae 5–6.5 X 1.5–2.5 µm, medio constrictae; mucus 5.5–8 X 4–7 µm. Conidia hyalina, laevia, elliptica, leviter vel valde curvata, 9–14 (14.5) X (3.2) 3.5–5.0 µm. Hyphae hyalniae, fibulatae, 1.5–2.5 (3.0) µm crassae. Typus DAOM #193363.

Assimilative Hyphae developing within living nematodes infected by adhesive conidia or caught by adhesive knobs on the external hyphae, hyaline, with clamp connections, (1.0) 1.5–2.5 (3.0) µm diam., filling the body of the host and digesting its contents, then perforating the cuticle to emerge as external, fertile hyphae. **Fertile Hyphae** hyaline, with clamp connections, moderately sparse, up to 1 mm long X (1.0) 1.5–2.5 (3.0) µm diam., bearing adhesive knobs, and conidia that are borne on fine pegs 0.5–4 µm long X 0.2–0.4 µm, sometimes swollen to 1 µm diam. at the base. **Predatory Adhesive Knobs** primarily terminal, occasionally intercalary on branches 3–23 µm long X 2.0–2.5 µm diam., the hour-glass cells 5–6.5 X (1.5) 1.8–2.5 µm, surrounded by a mucoid drop 5–9 X 4–7 µm. **Aleuriospores** none. **Conidia** hyaline, broadly cylindric and slightly to strongly curved in the middle or

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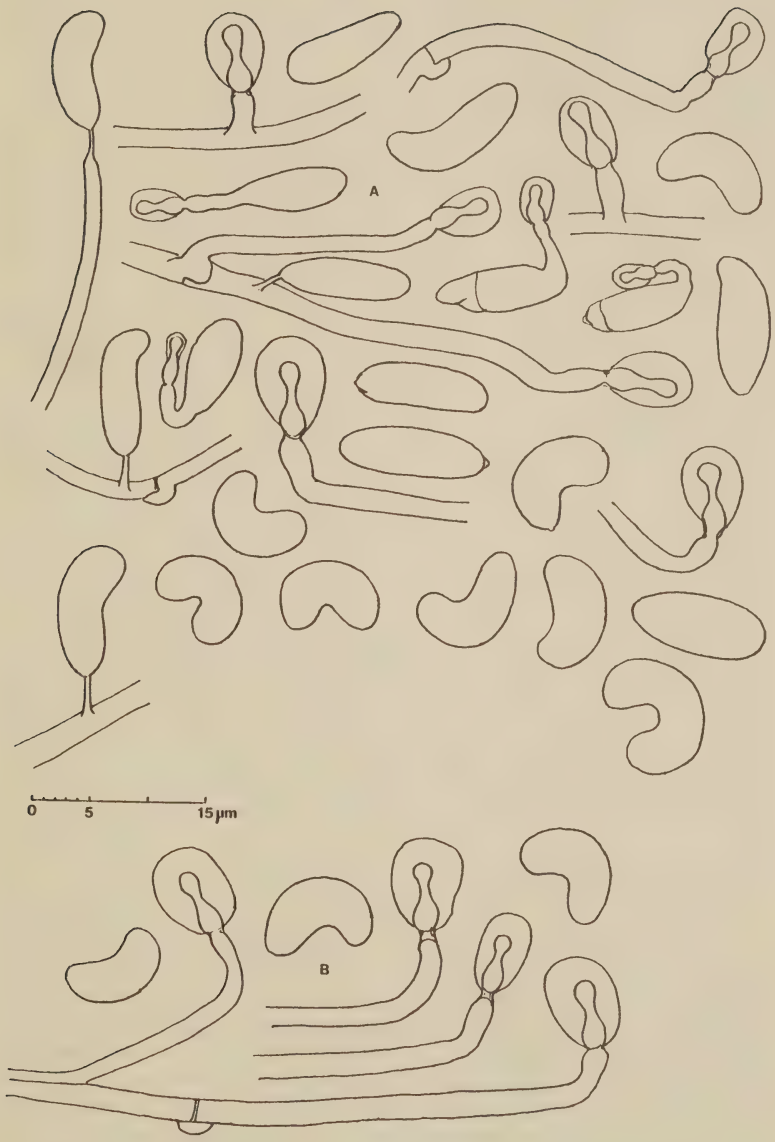
Figure 13 A–B: *Nematoctonus subreniformis* A) T-137 (N84-240), conidia, showing variation in shape, fertile hyphae, germinated conidia with adhesive knobs, and predatory adhesive knobs. B) T-140 (N84-243), conidia and terminal predatory adhesive knobs.


A
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15 µm
B

toward the tip, 9–14 (14.5) X (3.2) 3.8–4.8 (5.0) μm, germinating to form an adhesive knob at the end of a usually curved germ tube, 3.5–4.5 X 1.5–1.8 μm, the adhesive mucus 4–5 X 2.5–3.5 μm.
Teleomorph: None known.
Hosts: Both *Rhabditis terricola* and *Panagrellus redivivus* were readily attacked, by both adhesive conidia and predatory adhesive knobs.
Habitat and Distribution: *Nematoctonus subreniformis* has been isolated from only one locality, the hardwood forest at the West Gate of Algonquin Provincial Park, Ontario. It was recovered in 1983 and 1984, in three samples of humic, rotted hardwood, from different spots within that locality.
Isolates Studied: West Gate, Algonquin Provincial Park, Ontario, N83–147 (= T–108), N84–240 (= T–137; source of type specimen, DAOM #193363), and N84–243(1–3) (= T–138, T–139 and T–140).
Observations: The conidia of this species are so variable, even under similar conditions, that three infected nematodes in one centrifuge plate were thought to have been infected by three different species of *Nematoctonus*. They were all cultured (T–138 to T–140), and found to be identical. At times the conidia are plump and elliptic, sometimes cylindric with a decurved apex, and sometimes broadly sausage-shaped. These reniform conidia are the most typical of *N. subreniformis*, which is also characterised by its small, generally terminal, adhesive knobs. *Nematoctonus subreniformis* is otherwise similar to *N. geogenius*, and may only be a variation of that form-species. Nonetheless, the three isolates named above appeared distinct enough to be described as separate until their true relationships are known. *Nematoctonus subreniformis* differs from *N. haptocladus* by its stout, often strongly curved, conidia.

PART II: TAXONOMY OF THE RESUPINATEAE IN ONTARIO

Barron and Dierkes (1977) showed that a *Hohenbuehelia* was the sexual reproductive state of an Ontario isolate of *Nematoctonus*. Thorn and Barron (1984) reported that five species of *Hohenbuehelia* and one species of *Resupinatus* had *Nematoctonus* states which attacked and consumed nematodes. Singer (personal communication) indicated that *Nematoctonus* states probably only occurred within the tribe Resupinateae, which includes the genera *Hohenbuehelia*, *Resupinatus*, *Asterotus* (sometimes considered a subgenus of *Resupinatus*), *Aphyllotus*, *Stigmatolemma*, and *Stromatocyphella* (Singer 1962, 1975). Although species of *Panellus*, *Campanella* and

Faerberia have many similarities in habitat, morphology and anatomy, those tested were non-nematophagous (Thorn and Barron, 1984). A review of some of the taxonomic history of the Resupinateae, particularly those species treated in this study, follows.

The gilled members of the Resupinateae were previously known largely under the name *Pleurotus* (Fr.) Kummer (1871). Fries (1821) included the species he knew in his "tribe" (actually subgenus) *Pleurotus* of the almost all-encompassing genus *Agaricus*. Many subsequent mycologists did not agree that the species that now make up the Resupinateae were congeneric with the large and fleshy species, such as *Pleurotus ostreatus*, the type of *Pleurotus*. Since 1821, at least 10 genera have been created to accommodate various species in this group.

Resupinatus was proposed by S.F. Gray (1821) for the cupulate, resupinate species, *Agaricus applicatus* Batsch. *Phyllotus* Karsten (1879) and *Calathinus* Quélet (1886) included *A. applicatus* when described, and are obligate typonyms of *Resupinatus* Gray (Voss et al., 1983, Article 63). *Hohenbuehelia* Schulzer (in Schulzer et al., 1866) was based on *Agaricus* (*Pleurotus*) *petaloides* Bulliard: Fries. It was not until 1871 that Kummer raised *Pleurotus* to the generic level, but it has since gained widespread acceptance. In contrast, *Resupinatus* Gray (1821) was not used again until Murrill (in Murrill et al., 1915) revived it, and *Hohenbuehelia* was lost until Donk (1949) showed that it was validly published and Singer (1951) brought it into use. Since *Pleurotus* (Fr.) Kummer (1871) included both *Agaricus applicatus* and *A. petaloides* when described, it would have been an obligate typonym of *Resupinatus* Gray (1821) and *Hohenbuehelia* Schulzer (Schulzer et al., 1866) if it had not been conserved against both of these genera (Donk, 1949).

North American gilled members of the Resupinateae have been treated in monographs by Peck (1886), Murrill (1916; and Murrill et al., 1915), Pilát (1935), Coker (1944), Miller and Manning (1976), Libonati-Barnes (1981), and Miller (in press). Confusion of species concepts has been a problem, especially in the monograph by Pilát (1935), and many names were misapplied, by Pilát and others. Peck (1886) treated six species of *Pleurotus* that belong in the Resupinateae. Of these, only *P. atrocaeruleus* var. *griseus* and *P. striatulus* are treated under the same trivial names today (in *Hohenbuehelia* and *Resupinatus*, respectively).

Singer (1951 a) placed the gelatinized, pleurotoid agarics with inamlyoid spores in the tribe Resupinateae of

the Tricholomataceae. Species with metuloids went into *Hohenbuehelia*, and those without into *Resupinatus*. Kuehner and Romagnesi (1953) treated *Resupinatus* and *Hohenbuehelia* as the subgenera *Phyllotus* and *Acanthocystis* of *Geopetalum*. Kuehner (1980) placed all of these species in *Resupinatus*.

Miller (in press), in a preliminary monograph of the species of *Hohenbuehelia* of North America, follows essentially the species concepts of Coker (1944), plus he provides descriptions and illustrations of the characters of anatomy and micromorphology that are emphasized in modern classifications. *Hohenbuehelia* is characterized by the gelatinized pileus, inamyloid, elliptical spores, and capitate, fusoid cheilocystidia. Miller transferred *Resupinatus cyphelliformis*, *Pleurotus silvanus* sensu Coker and *Pleurotus unguicularis* sensu Coker to *Hohenbuehelia*. Earlier, Miller (Miller and Manning, 1976) treated these species in *Pleurotus* because they all had the elliptical spores and fusoid cheilocystidia so common in *Pleurotus* but not found in *R. applicatus*, the type of *Resupinatus*. Miller (in press) reunited these species with the other species of the Resupinateae, with which they form a more natural group.

The species of the Resupinateae without gills, termed cyphelloid, or "reduced" agarics, were treated in large and unnatural genera such as *Cyphella*, *Solenia* and *Porotheleum* and were more or less lost until their similarity to species of *Resupinatus* was recognised by Romagnesi (1953, in Donk, 1962 b), Donk (1962 b), and Singer (1962, 1975). Despite these similarities, the cyphelloid species have never been included with the gilled members of the Resupinateae in any monograph. Their biology is relatively unknown.

Our aim was to identify and describe the species of the Resupinateae that occur in Ontario, in order to provide a basis for connecting *Nematoctonus* anamorphs with their teleomorphs in the Resupinateae.

MATERIALS AND METHODS[1]

This portion of the study was based on examination of about 300 specimens of the Resupinateae at the University of Toronto Cryptogamic Herbarium (TRTC) and the National Mycological Herbarium in Ottawa (DAOM), plus fresh specimens collected in and around Ontario. Acronyms of herbaria are those used in Holmgren et al. (1981). The publication dates of taxonomic works are those accepted by Stafleu (1967) and Stafleu and Cowan (1976-1983).

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[1]See Appendix 1: Media and Reagents.

A: EXAMINATION OF SPECIMENS

Notes on fresh specimens, recorded soon after collection, included colours, texture, taste, odour, and other characters that would be lost or changed on drying. Colours were recorded in descriptive terms and in the standard code of Kornerup and Wanscher (1978). Spore prints were obtained on white paper. No chemical spot tests were made. Collections were air-dried on screen racks 30-50 cm above two 100 watt household lightbulbs.

Herbarium specimens were hand-sectioned for study of microscopic characters using burdock (*Arctium* sp.) pith to support the wedge of the specimen being sectioned. The mountants most commonly used were water, 3% KOH in water, Melzer's reagent and solutions of Brilliant Cresyl Blue and Trypan Blue. Water mounts allowed the study of natural colours and hyphal encrustations that dissolve in other mountants. Tissues of dried specimens were revived in 3% KOH without added stain since slides were examined using phase-contrast microscopy. Melzer's Reagent was used primarily to test colour reactions of spores, metuloids and hyphae, but also to highlight hyphal encrustations. Brilliant Cresyl Blue was used to highlight gelatinous zones and metuloids.

The substrate beneath the fruiting bodies was identified and searched for conidia of a possible *Nematoctonus* state, adhesive knobs, or other characters of the vegetative hyphae. Woody substrates were sectioned, and soil was crumbled then centrifuged (as in Part I) to separate fungal hyphae and spores from soil particles. These preparations were usually examined in trypan blue.

B: TAXONOMIC CHARACTERS

The taxonomic characters used in the Resupinateae are those in use throughout the Agaricales (see Singer, 1975). The terms used for macroscopic characters are in agreement with those used by Largent (1973) with one exception. The term used herein for narrowly obovate fruit bodies is spathulate (Largent, 1973, calls this petaloid). Petaloid is used in this paper to describe the shape of *Hohenbuehelia petalodes*, which is actually semi-infundibuliform (see Fig. 24).

Microscopic features are essential in the classification or identification of the Resupinateae. They might be divided into features of general fruit body anatomy and construction, features of the hymenium, the cuticle, and the spores. An attempt has been made to follow the terminology of Singer (1975) and Largent et al. (1977).

The fruit body is usually made up of a number of

layers, with a gelatinous zone usually directly beneath the cuticle. This gelatinous zone is a characteristic feature of the Resupinateae. In this zone thin hyphae (actually the narrow, refractive lumens) are generally widely dispersed in a gelatinous matrix (generally formed by highly gelatinized outer walls), and may be arranged more or less horizontally (radially or tangentially), vertically, or in a tangle. Singer (in Singer and Kuthan, 1980) places great taxonomic emphasis on the arrangement of the hyphae in the gelatinous zone, whereas Donoso (1981) believes that there is too much variation within fruit bodies and between collections of some species to be useful. While there is some intraspecific variation in this character, certain useful patterns emerged among many collections. The depth of the gelatinous zone was also an important character to Kuehner (in Kuehner and Romagnesi, 1953, 1954) and Singer (in Singer and Kuthan, 1980). Singer gave explicit instructions on where and how to measure the depth of the gelatinous zone, emphasising that no pressure should be applied to the cover-glass before it is measured. Measurements of anatomical zones were made with no cover-glass over the sections, as even allowing the cover-glass to settle on the section in ample mountant could double the thickness of the gelatinous zone.

Beneath the gelatinous zone is usually a less gelatinized layer of densely-woven, thicker hyphae, that is occasionally divided by a second gelatinous zone. When this zone (the trama, or trama proper) is thin or absent, the fruiting body appears transparent. The walls of the hyphae in this zone may be thin, or thickened and gelatinized. This zone usually extends into the lamellae to form the lamellar trama, in which the hyphae are arranged vertically in a parallel to slightly interwoven fashion (regular to subregular). The pigmentation of the lamellar trama, subhymenium and hymenium can be taxonomically important.

In the hymenium, the colour, shape, size, and number of sterigmata of the basidia, and the presence, colour, shape, and size of cystidia are valuable taxonomic characters. Thick-walled, lanceolate cystidia (metuloids, or lamprocystidia) are characteristic of *Hohenbuehelia* (although sometimes inconspicuous) and lacking in *Resupinatus* (Singer, 1951 a, 1975). These metuloids are usually metachromatic in cresyl blue (turning bright magenta), and inamyloid to faintly dextrinoid (turning pale brick-red in Melzer's reagent).

Most species of *Hohenbuehelia* have a second type of cystidium in addition to metuloids that are thin-walled, and often have a tapering neck that is capped with an hour-glass

secretory cell and its mucoid droplet. The apex of these cystidia (Fig. 22 B, E, and G) resembles the adhesive processes found in *Nematoctonus*. We name this distinctive capitulum a gloeosphex, so that cystidia bearing such capitula may be referred to readily. **Gloeosphex cystidia** are distinct from secretory cystidia found in other agarics, such as *Baeospora* and *Gloiocephala*, and are diagnostic for *Hohenbuehelia*. These occur most commonly as cheilocystidia, but also as pleuro-, pilo- and caulocystidia. The gill edge is often a sterile zone of cheilocystidia mixed with metuloids (Fig. 16 D).

The gill margins of *Resupinatus* species are commonly sterile, with a type of cystidium not found in *Hohenbuehelia*. These are club-shaped cells with irregular, knobbed, tapering, or finger-like branches at their tips (Fig. 28 A and F). These diverticulate cheilocystidia are diagnostic for *Resupinatus*. *Asterotus* and *Stigmatolemma* have diverticulate cheilocystidia (surrounding the cap margin in *Stigmatolemma*), indicating their affinities with *Resupinatus*.

Characters of the cuticle (or pileipellis), including the epicutis of tomentum or other superficial hyphae, are taxonomically valuable in the Resupinateae. In *Hohenbuehelia*, the cuticle usually consists of repent, interwoven hyphae (a cutis) in a thin zone that is poorly distinguished from the gelatinous zone beneath. The hyphae of the cuticle, however, tend to be broader and more pigmented (often opaque) than those of the gelatinous zone. Pigmentation may be intracellular or extracellular, and in the latter case may take the form of distinct hyphal encrustations or amorphous masses between hyphae. The epicuticular hyphae are generally hyaline, and may have thin, thickened, gelatinized, or encrusted walls. Singer (1977) emphasizes the degree of hyphal encrustation, but its value as a taxonomic character in *Hohenbuehelia* is questioned, since it varied between sections from a single fruit body and from fruit bodies of a single collection. *Resupinatus*, *Asterotus*, *Stigmatolemma* and *Stromatocyphella* all have a cuticle of diverticulate hyphae. In *Asterotus*, these diverticulate hyphae form a deep layer (an asterostromelloid layer or dichophysoid layer). The branchlets are cylindric, and the hyphae are not encrusted. In *Resupinatus*, *Stigmatolemma* and *Stromatocyphella* the branchlets are knobbed, tapering or irregular, and certain branchlets exude a substance that forms yellowish or brownish crystalline or amorphous encrusting material. This encrusting material is often so copious as to obscure

details of the hyphae.

The basidiospores of the Resupinateae show a relatively small range of variation, but what variation there is is sometimes diagnostic at the species level. The spores are white or nearly white in print, and hyaline, inamyloid, acyanophilic, and smooth under the light microscope. They range in shape from globose to elliptic, bean-shaped (phaseoliform) or sausage-shaped (allantoid). Basidiospores of the Resupinateae have thin walls, and collapse readily (Coker, 1944; Vandendries 1934), and are considered similar in this regard to those of *Pleurotus* (Pegler and Young, 1971). An attempt was made to measure 20 or more spores from each collection examined (measurements exclude the length of the hylar appendage). In reporting spore sizes (and other measurements where large populations were sampled), figures in parentheses represent those dimensions that appeared in less than 10% of all observations.

C: CULTURAL STUDIES

Single-spore, monokaryotic cultures and dikaryotic cultures were obtained when possible from fresh collections. Dikaryotic cultures were obtained by allowing minute portions of fruit body tissue to grow out onto PD+AB agar, or by allowing two to several monokaryotic cultures to anastomose.

Single-spore cultures were obtained in the following way. A small, clean portion of a cap was suspended with Vaseline from the lid of a petri plate so that it shed spores onto the agar below. When the spore deposit was visible to the naked eye, a small block of agar with spores was transferred aseptically to approximately 5 mL of sterile saline in a vial. The vial was recapped and shaken to suspend the spores. Dilutions were prepared using sterile saline, and 0.5-0.75 mL of dilute spore suspension spread evenly over the surface of a PD+AB agar plate.

Spore dispersion plates were scanned under 40X or 100X over the next few days (up to 3 weeks in *Resupinatus striatulus*) following inoculation. Once widespread germination was observed, single germinated basidiospores were transferred aseptically, each on a minute chip of agar, to a plate of PD+AB or ANT B agar. The ANT B agar was particularly useful for the slow-germinating species, since bacteria resistant to tetracycline alone seemed to build up during the long germination period, and the slow species could not outgrow them.

Single-spore cultures were checked for the absence of clamp connections after they had grown out to 5 mm diameter

or more. Clampless isolates were maintained on PDA for mating studies. Mating tests were conducted by plating a small piece from the margin of one single-spore culture together with an overlapping piece from another, and so on two by two in all possible combinations. Once good growth had been achieved, the circumference of the resulting colony was checked for clamp connections under 100X of the compound microscope. In some cases, because of the fine hyphae in this group, the presence of clamp connections had to be confirmed in a slide mount under 400X interference contrast. The results were scored in a matrix, which indicated the mating groups.

Studies on the nematophagous capabilities of cultures, and description of their *Nematoctonus* states, were conducted on WA in the presence of nematodes, as described fully in Part I.

RESULTS AND DISCUSSION

Tribus **RESUPINATEAE** Singer (1948 a: 30)

Type genus, originally designated: *Resupinatus* (C. Nees) S.F. Gray

The following description is adapted from Singer (1975): Fruit bodies pleurotoid, omphalinoid or cyphelloid (discoid to urceolate); lamellate or not; basidia normal, ie. not with siderophilous granules; basidioles clavate; spores white or whitish in mass, hyaline, inamyloid, acyanophilic, variously shaped, smooth; cheilocystidia usually present, sometimes inconspicuous, thin-walled, hyaline, often with hour-glass secretory cells as capitellae; pleurocystidia present as metuloids or absent; context soft and usually flexible when fresh, consisting of inamyloid tissue which is usually at least partially gelatinized; the gelatinous zone, trama or cuticle, or all three, usually with intracellular or extracellular, sometimes encrusting, grey to brown or black pigments; hyphae monomitic, with clamps; cuticle a poorly-differentiated cutis, or with diverticulate, tangled tomentum hyphae forming an encrusted rameales structure or a non-encrusted asterostromelloid zone. Most frequently on decaying wood, on other decaying vegetation, on soil rich in organic matter, or on diseased tissue of living Cormophyta. **Observations**: The key features of the Resupinateae are the gelatinized fruit bodies with monomitic, clamped hyphae and nonamyloid spores, and usually some brownish or blackish pigmentation. The tribe represents a natural and closely related group. The members of the Resupinateae probably all

lead a parasitic existence, which is most easily shown in *Hohenbuehelia*, but also suggested in *Resupinatus* and *Stigmatolemma*. All species of *Hohenbuehelia* tested possess *Nematoctonus* states, and consume nematodes. The fact that species of *Resupinatus* do not consume nematodes makes this genus more interesting, in a way, than *Hohenbuehelia*. The peculiar, jack-shaped cells of *Resupinatus applicatus* were not observed to become detached and germinate, and their function remains unknown. Vegetative hyphae of *R. striatulus* were followed through and along the surface of the substrate. Although these hyphae were often observed in areas of high microbial activity, and found closely associated with free-living green algae on the surface of the rotted wood, conclusive evidence of the biology of this fungus was not found. *Resupinatus striatulus* (Fig. 32 D) and *Stigmatolemma poriaeforme* (Fig. 32 B, C) have microdroplets on vegetative hyphae in the substrate of fruiting bodies similar to those found in *Pleurotus* (Fig. 32 A). No cultures of *Stigmatolemma* were available for study, but the microdroplets of *R. striatulus* were not found in culture, either on nutrient media or on WA with nematodes.

The tribe Panelleae (Tricholomataceae) has a number of similarities with the Resupinateae. Members of the Panelleae are often pleurotoid in habit, have a gelatinous zone in their cap trama, and some have metuloids, while others have diverticulate cheilocystidia. The Panelleae can be distinguished by their amyloid spores. Two species of *Panellus* tested in this laboratory were non-nematophagous (Thorn and Barron, 1984; and unpublished data).

The parasitic habit in the Resupinateae raises the question of relationships to the genus *Pleurotus*. Fruit bodies of *Pleurotus* species are generally large, fleshy, and non-gelatinized. Hilber (1982) has illustrated secretory cheilocystidia in certain species of *Pleurotus* that resemble those of species of *Hohenbuehelia* and of *Resupinatus alboniger*. *Pleurotus* is classified by Singer (1975) in the Polyporaceae of the Agaricales (often referred to as the Pleurotaceae, a later synonym, to avoid confusion with the majority of the polypores that belong to the Aphyllophorales).

The evolutionary kinship between *Pleurotus* and the Resupinateae appears clear. Members of the Resupinateae and *Pleurotus* share the parasitic mode. The similarity of the cheilocystidia in *Pleurotus* to those in the Resupinateae is striking. The spores of both *Pleurotus* and *Hohenbuehelia* are hyaline, thin-walled, and readily collapsing, and are regarded as similar to each other, and to those of

Polyporus, type genus of the Polyporaceae (= Pleurotaceae) by Pegler and Young (1971). The microdroplets found in *Resupinatus* and *Stigmatolemma* resemble those in *Pleurotus*. In addition, the dolipore septa in *Nematoctonus leiosporus* were shown to be of the "polypore type" (Tzean and Estey, 1977). These facts are strong evidence of the relatedness of these groups, despite the large morphological differences in their fruit bodies, and suggest that the Resupinateae should be transferred from the Tricholomataceae to the Polyporaceae (= Pleurotaceae).

KEY TO THE TAXA OF THE RESUPINATEAE STUDIED

1. Fruit bodies with definite gills **2**
1. Fruit bodies much reduced, without gills **23**
    2. Metuloids present in gills **3**
    2. No metuloids present in gills **16**
3. Fruit bodies usually 2 cm large or larger **4**
3. Fruit bodies usually less than 1 cm broad **10**
    4. Fruit bodies centrally stipitate, or nearly so; in bogs ..... *Hohenbuehelia longipes*
    4. Fruit bodies sessile or laterally stipitate **5**
5. Fruit bodies reniform or dimidiate **6**
5. Fruit bodies spathulate or petaloid **7**
    6. Spores ovate, 7–9 X 4–5.5 µm; fruit bodies pearl grey to brownish, with thick gelatinous spines ..... *Hohenbuehelia mastrucata*
    6. Spores narrower, 6.5–8.5 X 3.2–4.2 µm; upper surface glabrous to tomentose or hirsute, colour variable ..... *Hohenbuehelia atrocaerulea* var. *grisea*
7. Spores short, ovate, subglobose or globose, 3.0–5.5 X 3.0–4.0 µm ..... *Hohenbuehelia angustata*
7. Spores longer and usually more elliptical **8**
    8. Spores mostly ovate or short elliptic, 5.5–7.5 (9.0) X 3.0–4.5 µm, on trunks, woody debris or soil **9**
    8. Spores elliptic to phaseoliform, 7.5–9 X 4–5 µm; usually in mossy coniferous woods ..... *Hohenbuehelia tremula*
9. On soil or woody debris; fruit body petaloid, often thick-fleshed; gelatinous zone of ascendant hyphae, 100–250 µm deep ..... *Hohenbuehelia petalodes*
9. On logs; fruit body spathulate, thin-fleshed; gelatinous zone of horizontally-arranged hyphae, 40–100 µm deep ..... *Hohenbuehelia* stirps Petaloides (see comments under *Hohenbuehelia petalodes* and

Nematoctonus cylindrosporus)

10. Gills white or yellowish at maturity; metuloids with hyaline walls **11**

10. Gills dark-coloured at maturity; metuloids usually with brown walls **12**

11. Cap dimidiate, straw-coloured or pale brown; gills moderately close ..... *Hohenbuehelia approximans* (see also small forms of *H. atrocaerulea* var. *grisea*)

11. Cap cupulate, grey-brown to black; gills few and distant ..... *Hohenbuehelia cyphelliformis*

12. Metuloids inconspicuous, imbedded in hymenium, often clavate **13**

12. Metuloids lanceolate, projecting clearly **14**

13. Cap with silvery tomentum over blackish flesh; on hardwood branches, often *Populus* .... *Hohenbuehelia unguicularis*

13. Cap jet black, mostly glabrous, with fine wisps of white hairs; on conifers, often *Abies* and *Pinus* ..... *Hohenbuehelia pinacearum*

14. On conifers (*Pinus*); cap jet black, tomentose ..... *Hohenbuehelia mustaliensis*

14. On hardwoods **15**

1.5 Cap jet black, mostly glabrous, with fine white hairs ..... *Hohenbuehelia nigra*

15. Cap brown or olive brown, tomentose, often with dark bristles ..... *Hohenbuehlia reniformis* (see under *Hohenbuehelia approximans*)

16. Spores globose or subglobose **17**

16. Spores elliptical or allantoid **19**

17. Cap with shaggy tomentum over basal area **18**

17. Cap at most pruinose, usually cupulate, less than 8 mm broad ..... *Resupinatus striatulus*

18. Basal tomentum greyish or yellowish .... *Resupinatus applicatus*

18. Basal tomentum black, often in a clearly-defined disk ..... *Resupinatus trichotis*

19. Gills becoming grey, brown or black at maturity; spores elliptic-phaseoliform **20**

19. Gills white; spores allantoid .... *Hohenbuehelia cyphelliformis*

20. On conifers; cap black, mostly glabrous, with fine white fibrils ..... *Hohenbuehelia pinacearum*

20. On hardwoods; cap tomentose, white, greyish or brownish **21**

21. Fruit bodies spoon-shaped, with a well-defined stem, brown, drying snow white, tomentose .... *Asterotus dealbatus*

21. Fruit bodies cupulate, sessile or with a short lateral pseudostipe **22**
    22. Hyphae of epicutis basically smooth, without lobes or branchlets; cap usually drawn into a pseudostipe ..... *Hohenbuehelia unguicularis*
    22. Hyphae of epicutis with lobes and finger-like branches; cap usually sessile, dorsally attached ..... *Resupinatus alboniger*
23. Spores globose or subglobose 3.5–6.0 X 3.0–5.0 µm; fruit bodies minute, in troops .... *Stigmatolemma poriaforme*
23. Spores elliptic or cylindric **24**
    24. Spores elliptical, 6–9 X 3–4 µm; fruit bodies minute; in troops on conifers .... *Stigmatolemma conspersum* (see under *S. poriaeforme*)
    24. Spores cylindric, 8–10 X 3.0–3.8 µm; fruit bodies cupulate, clustered on a gelatinous base ..... *Stromatocyphella conglobata*

ASTEROTUS Singer (1943 b: 161)

Type species (only original species): *A. dealbatus* (Berkeley) Singer

= *Resupinatus* (C. Nees) S.F. Gray subgenus *Asterotus* (Sing.) Singer (1973: 30)

The following description is modified from Singer (1962), based on examination of specimens during this study, with significant deviations from the original description indicated in bold face: Habit pleurotoid, pileus flabelliform on a well-formed, compressed or terete but lateral stem; gills well-formed, decurrent. Surface layer of the pileus and stipe formed of an asterostromelloid zone of hyaline hyphae with innumerable short, crowded, cylindric side branches coming off at right angles in all directions; **trama proper strongly gelatinised, deep brown in mass but hyaline in section**; hyphae monomitic but sometimes with thickened, gelatinised walls, inamyloid, all with clamps; basidia normal; **cheilocystidia clavate-digitate to diverticulate, sometimes abundant and forming an asterostromelloid zone on gill edge**; spores white in print, cylindric, subfusoid or suballantoid, hyaline, inamyloid, smooth. On wood.

Observations: The pigmented, gelatinized trama, inamyloid spores, and diverticulate cheilocystidia show that *Asterotus* is a typical member of the Resupinateae, closely allied with *Resupinatus* sensu stricto. The diagnostic features that

separate *Asterotus* from *Resupinatus* are the strongly stipitate, flabelliform habit, and the thick asterostromelloid zone covering the cap and stem, the branchlets of which are cylindric and do not secrete amorphous or crystalline encrusting material. Species of *Resupinatus* are resupinate, cupulate to broadly pseudostipitate, and the coralloid diverticulae of its cuticular hyphae are knobbed, tapering or irregular, and secrete amorphous or crystalline, hyaline to brown encrusting material.

As it is now circumscribed, *Asterotus* is monotypic. *Asterotus chilensis* (Sing.) Singer (Singer and Digilio, 1953) is better placed in *Resupinatus* where it was originally described (Singer, 1948 b). *Resupinatus chilensis* is close to *R. striatulus*, or possibly conspecific. *Asterotus graminus* Singer (1969) has been placed by Singer (1973) in *Resupinatus*, where it is close to *R. striatulus*. *Asterotus argentinus* Singer (Singer and Digilio, 1953) has been synonymised with *Resupinatus alboniger* (Pat.) Sing. by Singer (1978). Finally, *A. bicolor* (Mont.) Singer (1955) is a synonym of *A. dealbatus*.

Asterotus dealbatus (Berk.) Singer (1943 b: 161) Fig. 15
= *Panus dealbatus* Berkeley (1847: 317)
= *Panellus dealbatus* (Berk.) Murrill, in Murrill et al. (1915: 245)
= *Resupinatus dealbatus* (Berk.) Singer (1973: 30)
= *Panus bicolor* Montagne (1854: no. 329)
= *Asterotus bicolor* (Mont.) Singer (1955: 376)
= *Resupinatus bicolor* (Mont.) Singer (1973: 30)
= *Panus sprucei* Berkeley (1856: 142)

This species was not seen in the fresh state. The following description is based on two dried specimens exmained during this study:
Fruit Body flabelliform and laterally stipitate, up to 2.5 cm tall by 1.2 cm broad, entirely matted-tomentose, particularly the stipe. **Pileus** white, to clay-coloured (pale 4B2) at the base, where it fans out from stipe; the margin finely tuberculate-striate. **Stipe** terete, 4-12 mm tall X 1.5-3 mm, with a bulb formed by substrate tightly bound to mycelioid base. **Gills** decurrent by fine white lines onto the stem, narrow, close and blackish. **Cuticle** a deep asterostromelloid zone formed of hyaline diverticulate hyphae about 3 µm diam., with cylindric projections up to 6 µm long by 1.0-1.5 µm (some fragments look like "jacks"). **Gelatinous Zone** forming entire trama, brown in mass, subhyaline in section, of hyphae 2-4 µm diam. in a strongly

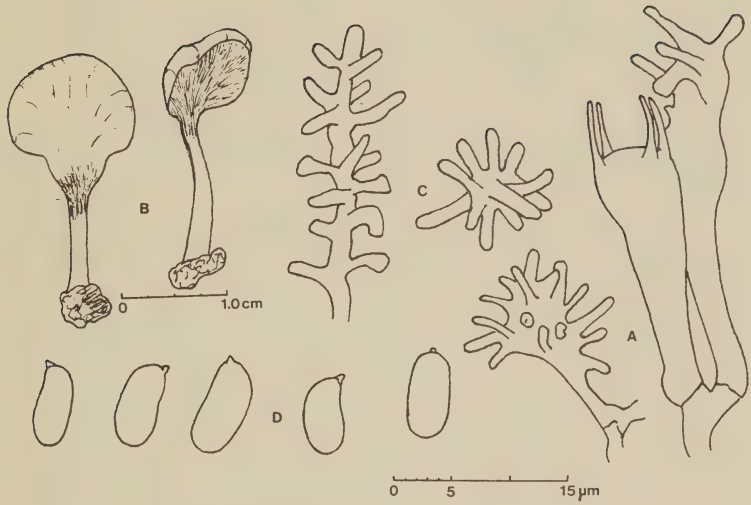

Figure 14 A-D: *Asterotus dealbatus*, Smith s.n. (Sept. 4, 1955, MICH); A) A basidium and two cheilocystidia; B) two fruit bodies; C) cuticular hyphae; D) basidiospores.

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gelatinized matrix. **Basidia** 4-pronged, clavate, 22-26 X 6-7 µm. **Cheilocystidia** clavate, or vesiculose, highly diverticulate, 12-25 X 4-10 µm. Similar pleurocystidia present **Spores** hyaline, inamyloid, smooth, narrowly elliptic-phaseoliform, (5.0) 6.0-7.0 X 2.5-3.0 µm.
Habitat: On dead wood. The 2 specimens examined were on soft, brown-rotted hardwood.
Distribution: *Asterotus dealbatus* is known from Alabama, Missouri, New York, North Carolina, Ohio (Murrill, et al. 1915) and Michigan in the United States, Quebec in Canada, and Brazil (Corner, 1981). The type of *Panus sprucei* came from southern Brazil, and that of *P. bicolor* came from French Guiana.
Specimens Examined: **Canada**: **Quebec**: Aylmer, west of Victoria Park, Sept. 11, 1893, J. Macoun, DAOM #51455. **United States**: **Michigan**: Warren's Woods, southwest Michigan, Sept. 4, 1955, A.H. Smith s.n. (MICH).

Mating System and Cultural Characters: Unknown.
Observations: *Asterotus dealbatus* is a striking and unmistakable fungus, particularly when dry. Its flabelliform habit and stark white upper surface, which contrasts strongly with the blackish-brown, decurrent gills, are very distinctive. The pigmented gelatinous zone in the cap, and the diverticulate cheilocystidia and cuticular hyphae place it clearly in the Resupinateae, close to *Resupinatus applicatus*. The cylindric diverticulae are, however, very different from the knobbed, tapering or irregular diverticulae found on similar hyphae of *R. applicatus*. Additionally, in *Asterotus* the cap tomentum forms a deep asterostromelloid zone (Singer, 1962), quite different from the epicutis of *R. applicatus*.

The illustration of *Panus sprucei* given by Berkeley (1856) matches perfectly the character of the specimens of *A. dealbatus* examined in this study. Berkeley described *P. sprucei* as "on a larger scale than *P. dealbatus*, and of a less pure white when dry". Other details of the description compare well with *A. dealbatus*. Singer (1955) reported on the type specimens of *P. sprucei* and *P. bicolor*, which he considered identical to each other. His description of them closely matches the description of *A. dealbatus*, including the spore size, given as 6.5-7.3 X 3.3 µm. On this evidence it is difficult to maintain *A. bicolor* (with *P. sprucei* as a synonym) and *A. dealbatus* as separate species.

HOHENBUEHELIA Schulzer, in Schulzer, Kanitz and Knapp (1866: 45) [as *Hohenbühelia*]
Type species (only original species): *H. petalodes* (Bull.: Fr.) Schulz.
= *Geopetalum* Patouillard (1887: 127)
Type species, obligatory under Article 7.11 of I.C.B.N. (Stafleu et al., 1978): *G. petalodes* (Bull.: Fr.) Pat. [Singer and Smith (1948) selected *G. carbonarium*, but this is inadmissible]
= *Pleurotus* (Fr.) Kummer sect. *Acanthocystis* Fayod (1889: 338)
= *Acanthocystis* (Fayod) Kuehner (1926: 111)
Type species, selected by Donk (1949), *A. geogenius* (DC. ex Fr.) Kuehner [= *H. petalodes* (Bull.: Fr.) Schulz.]
= *Marasmius* Fries sect. *Pleurotopsis* P. Hennings, in Engler and Prantl (1898: 226)
= *Pleurotopsis* (P. Henn.) Earle 412 (1909)
Type species, designated by Earle (1909): *P.*

spodoleucus (Berk. & Br.) Earle [= *Hohenbuehelia cyphelliformis* (Berk.) Miller]

= *Agaricochaete* Eichelbaum (1906: 58)

Type species, selected by Singer and Smith (1946): *A. mirabilis* Eichelbaum

= *Urceolus* Velenovský (1939: 44)

Type species, selected by Donk (1962 a), and only species fully described in original publication: *U. sambucinus* Velenovský [= *Hohenbuehelia cyphelliformis* (Berk.) Miller]

The original generic diagnosis of *Hohenbuehelia* (Schulzer et al., 1866) was based on *Agaricus petalodes* Bull.: Fr., and must be considerably revised to accommodate the now much wider limits of *Hohenbuehelia*. The following description is based on that by Singer (1975), with additional data from this study: Small to medium-sized agarics (0.5-10 cm) with well developed gills; gills decurrent or radiating from point of attachment or a central or eccentric point on the underside of the cap; habit cupulate, conchate, dimidiate, petaloid or omphalinoid; stem absent or present as a lateral pseudostipe or occasionally a well-differentiated central stipe; cap usually but not always with a partially gelatinized trama (most commonly forming a distinct upper gelatinous zone directly below cuticle); hyphae monomitic, inamyloid, all with clamp connections; cuticle occasionally a hymeniform layer of inflated hyphal tips, but more commonly a cutis, often poorly differentiated, commonly with tufts of hyphae forming a sparse or dense tomentum; pigments (grey to brown or black) usually present, intercellular or extracellular as distinct ring or spiral encrustations or as amorphous-granular material; cuticular hyphae not coralloid-diverticulate nor forming a rameales structure; spores white in mass, hyaline, inamyloid, acyanophilic, varying from globose to elliptic, phaseoliform, cylindric or allantoid, thin-walled, smooth (under light microscope); pleurocystidia usually present as metuloids although occasionally rare or inconspicuous; cheilocystidia present, clavate, fusoid or lecythiform, commonly with an hour-glass secretory cell surrounded by a mucous droplet (gloeosphex) at the tip of a short or elongated neck, the neck sometimes branched and with 2-4 gloeosphex capitellae; similar gloeosphex cystidia often occurring as pleurocystidia, pilocystidia or caulocystidia; gill trama regular but hyphae often interwoven to a degree, sometimes with thickened, gelatinized walls. On the ground, on wood or living or dead herbaceous plant material. Asexual state a *Nematoctonus*.

Observations: In Singer's (1975) system of agaric classification, *Hohenbuehelia* could be recognised by the presence of metuloids, inamyloid spores, and a gelatinous zone in the pileus. From this study, it can be added that species of *Hohenbuehelia* possess *Nematoctonus* anamorphs, usually indicated by the presence of gloeosphex cystidia on the gills, cap or stem of the fruit body.

Other genera with which *Hohenbuehelia* might be confused are *Resupinatus* sensu stricto, *Campanella*, *Panellus*, *Faerberia* and *Conchomyces*. Species of *Resupinatus* have diverticulate cheilocystidia and cuticular hyphae, and lack hour-glass secretory cells on their cystidia, and they lack a *Nematoctonus* asexual state. Kuehner (1980) treats *Resupinatus* and *Hohenbuehelia* as subgenera of *Resupinatus*, but uses some of the same characters to distinguish them. In particular, he illustrated clearly the diverticulate cheilocystidia and diverticulate cuticular hyphae of *Resupinatus*, and the gloeosphex cystidia of *Hohenbuehelia*. Species of *Campanella*, which occasionally have metuloids, also lack hour-glass cells and *Nematoctonus* states, and have anastomosing gills that form a poroid hymenium. Species of *Panellus* have amyloid spores. Singer (1951 a) included *Panellus serotinus* in *Hohenbuehelia* because of its metuloids, but has since (1962, 1975) excluded it on the basis of its amyloid spores. *Panellus patellaris* (Fr.) Konrad and Maublanc has a well-developed gelatinous zone in the cap, and allantoid spores similar in shape to those of *R. cyphelliformis*, but much smaller (4.5-5.5 X 0.5-1.2 µm fide Miller, 1970). Both *Panellus serotinus* and *P. patellaris* are non-nematophagous and have no *Nematoctonus* anamorph (Thorn and Barron, 1984; and Thorn, unpublished data). *Faerberia* Pouzar (1981), a monotypic genus including the species usually known as *Geopetalum carbonarium*, differs in its dimitic hyphal system and lack of a gelatinous zone, hour-glass secretory cells, or a *Nematoctonus* state. *Conchomyces* van Overeem (1928) is also monotypic, and based on *C. verrucisporus* v. Overeem [= *C. bursaeformis* (Berk.) Horak]. Reid (1964) and Singer (1975) treat this species as *Hohenbuehelia bursaeformis* (Berk.) Reid, but it differs from *Hohenbuehelia* in its spiny spores and clavate cheilocystidia lacking gloeosphex capitellae (Horak, 1981). The decision by Horak to separate *Conchomyces* from *Hohenbuehelia* seems to be biologically well-founded.

Donk (1949) showed that *Hohenbuehelia* had been validly published. Singer (1951 a) adopted *Hohenbuehelia* for species that he had previously treated in *Acanthocystis* (Singer, 1943 a). Kuehner and Romagnesi (1953) preferred *Geopetalum*,

with subgenus *Acanthocystis* for the species now in *Hohenbuehelia* plus *G. carbonarium*, and subgenus *Phyllotus* for the species of *Resupinatus* sensu lato. Pouzar (1981) showed that *Geopetalum* Patouillard (1887) is an obligate typonym of *Hohenbuehelia* under Article 63 of the International Code of Botanical Nomenclature (Voss et al., 1983) because it included the type species of *Hohenbuehelia* when it was first described. Pouzar erected the genus *Faerberia* to accommodate *G. carbonarium*, a carbonicolous fungus with dimitic trama, found in Europe.

The genus *Agaricochaete* and its two original species (Eichelbaum, 1906) have remained in relative obscurity until recently. Pegler (1977) described and illustrated a third species from Kenya, which he said differed from *Hohenbuehelia* in its centrally stipitate habit. The trama is non-gelatinized, but typical metuloids, and fusoid-capitate cheilocystidia are present, and thus *Agaricochaete keniensis* Pegler is most likely a *Hohenbuehelia* allied to *H. longipes*. A fourth species, *Agaricochaete indica* Natarajan and Raman (1980), is not congeneric since the hyphae lack clamp connections, the cheilocystidia are flexuous-cylindric, and the fruit bodies are purple and mycenioid. It is perhaps a species of *Lactocollybia*.

Pleurotopsis and *Urceolus* are generally synonymised with *Resupinatus* (Donk, 1962 a; Horak, 1968; Singer, 1975). The species on which they were both based is *Hohenbuehelia cyphelliformis* (= *Pleurotopsis spodoleucus*; = *Urceolus sambucinus*), so they become synonyms of *Hohenbuehelia*.

Hohenbuehelia angustata (Berk.) Singer (1951: 255) Figs. 15 & 16

= *Panus angustatus* Berkeley (1847: 318) [**non** *Panus angustatus* Berk., in Cooke (1892: 98); **non** *Pleurotus angustatus* Berkeley & Broome (1871: 528)]

= *Geopetalum angustatum* (Berk.) Murrill (1916: 300)

= *Pleurotus stratosus* Atkinson (1902: 116) (fide Murrill, 1916)

= *Acanthocystis stratosa* (Atk.) Singer (1943 a: 148)

= *Pleurotus petaloides* (Bull.: Fr.) Quélet var. *eupetaloides* Pilat f. *americana* Pilat (1935: 90) (fide Singer and Kuthan, 1980)

Pileus flabelliform to spathulate or dimidiate, 2-5 cm long X 1-4 (5)cm broad X 0.1-0.4 cm thick, margin incurved at

Figure 15: *Hohenbuehelia angustata*, R.G. Thorn #840722/03, X 1.5

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first, surface finely frosted near margin to downy tomentose near base with patches becoming glabrous in age. Ground colour off-white (A1) near margin to buff (4A2) or tan (5B3) near base, becoming darker in age to beige (4-5A3) and to warm brown (5C5) at base. **Gills** decurrent but ending in a tomentose sterile area on pseudostipe, narrow, close (6/mm), white at first, through buffy (4A2) to tan-coloured (5B4) in age or on drying, finely frosted under 10X by metuloids. **Stipe** none, though cap tapers to base (pseudostipe), which is 0.2-2 cm at point of attachment, with thick white rhizomorphs running through substrate from base. **Cuticle** a densely interwoven layer 8-15 µm thick of hyphae 1.5-5 µm diam., with clamps, with loose tufts of tomentum hyphae 50 µm or more tall, and scattered, prostrate **metuloid pilocystidia** 60-80 X 4-7.5 µm with hyaline to brownish walls about 1.0 µm thick. **Gelatinous Zone** immediately below, 180-250 µm thick, hyaline, of sparse,

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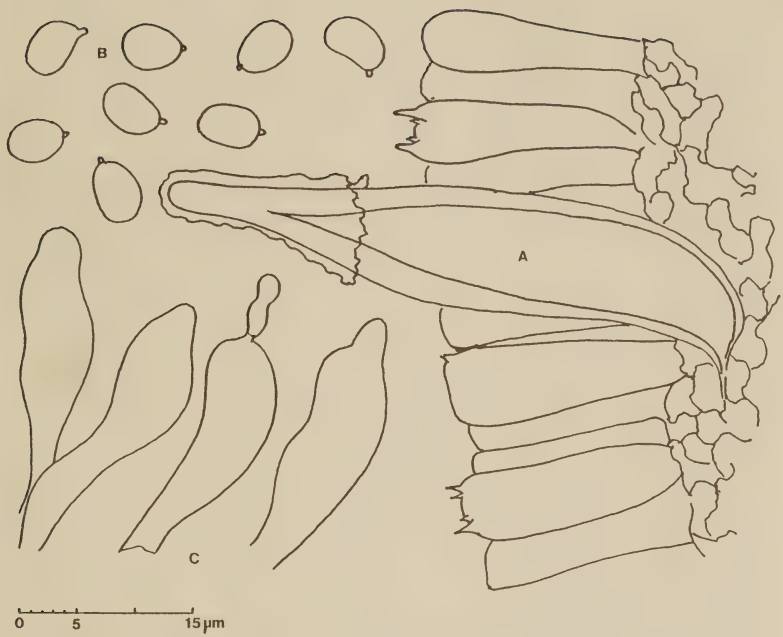
Figure 16 A-D: *Hohenbuehelia angustata*. A-C) RGT #830822/10 (T-87). A) Hymenium, showing basidia and one metuloid; B) basidiospores; C) cheilocystidia. D) RGT #830820/08 (T-92), vertical section at gill edge showing arrangement of basidia, metuloids and cheilocystidia.


B
A
C
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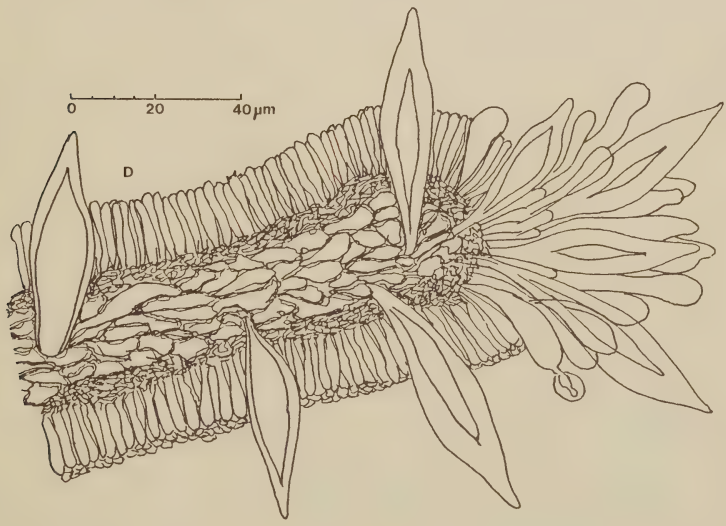
5
15 µm


0
20
40 µm
D

tangled hyphae 2–5 µm diam. (most about 3 µm), with clamps, in a gelatinous matrix. **Trama** bilayered, first a densely interwoven and slightly pigmented zone (yellow in KOH), about 20–35 µm thick, of hyphae 3.5–7 µm diam.; trama proper about 250–600 µm thick, of more loosely interwoven hyphae 4–9 µm diam (most 7 µm), with clamps. This layer extends down into gills to form gill trama. In gill interstices, immediately above subhymenium is a paler and more loosely woven zone (showing clearly in cresyl blue) 15–25 µm thick. **Subhymenium** hyaline, up to 10 µm thick, densely interwoven of much narrower hyphae, 1.5–3 µm diam. **Basidia** 4-pronged, clavate-cylindric, hyaline, 18–22 X 5.5–6.5 µm. **Metuloids** lanceolate, hyaline, pale brick red in Melzer's, becoming encrusted at their tips, 45–75 X 10–16 µm, with walls commonly 2.0 µm thick, up to 3.5 µm. **Cheilocystidia** numerous, fusoid to clavate or lageniform, thin-walled, hyaline, 25–36 X 7–8 µm, occasionally with an apical hour-glass 5–7 X 2–3 µm (most 6 X 2.5 µm), with or without a ball of mucus 4–7 µm diam. **Spores** white in print, hyaline, inamyloid, smooth, ovate to subglobose or globose, (2.5) 3.0–5.5 X (2.5) 3.0–4.0 µm. Older specimens often develop vegetative hyphae between their gills; these with the large hour-glass secretory cells typical of its *Nematoctonus* state, 8–11 X 3–5 µm.

Habitat: On spongy, brown-rotted hardwood logs.

Distribution: Northeastern North America, apparently most common around the Great Lakes, as Coker (1944) noted that it was rare in North Carolina.

Selected Specimens Examined: Canada: Manitoba: Victoria Beach, Aug. 1, 1927, G.R. Bisby and W.L. Gordon, DAOM #28054 and DAOM #157659. **Ontario**: Black Sturgeon Lake, Thunder Bay Dist., Aug. 11, 1974, S.A. Redhead, DAOM #175329; Cruickston Farm, Blair, July 22, 1984, RGT #840722/02 and #840722/03; Greenwood Conservation Area, Ontario Co., W. Dobrovolsky, Sept. 26, 1971, TRTC #47171; Pinery Provincial Park, Sept. 22, 1983, RGT #830922/10 (conf. R. Singer); Point Pelee National Park, Sept. 12, 1962, J.W. Groves, DAOM #89723; Rondeau Provincial Park, Aug. 12, 1983, RGT #830812/01 & #830812/02; same locale, Aug. 20, 1983, RGT #830820/05, #830820/08, & #830820/10; Temagami, July 22, 1968, J.W. Groves, DAOM #126095; Toronto, July 26, 1942, G.S. Bell, TRTC #20700. **Quebec**: Cantley, July 22, 1952, J.W. Groves, DAOM #33824 (part at TRTC) & DAOM #28862; Melocheville, June 24, 1981, R. McNeil, DAOM #185938; same locale, July 31, 1981, R. McNeil, DAOM #185914. **United States: Iowa**: Lodges St. Park, Boone Co., June 25, 1983, R.L. Gilbertson #14724 (ARIZ). **Kansas**: Rooks Co., July 24, 1896, E. Bartholomew,

Dearness #2760 (at DAOM). **Maine**: Old Town, Penobscot Co., July 12, 1970, R.L. Homola #3620 (MAINE). **Michigan**: Ann Arbor, July 26, 1921, L.E. Wehmeyer, DAOM #124163; East Lansing, Aug. 7, 1983, RGT #830807/02; Tahquamenon Falls, July 16, 1951, A.H. Smith, DAOM #26862. **New York**: Freeville, July 6, 1917, "J.H.F.", TRTC #1722; Ithaca, July 2, 1953, R.L. Shaffer, DAOM #41365; McGowan's Woods, July 16, 1903, H.S. Jackson #502 at TRTC; Varna Woods, July 13, 1903, H.S. Jackson #462 and #524 at TRTC [last 3 collections as *Pleurotus stratosus* Atkinson, det. G.F. Atkinson]. **West Virginia**: Stuart Camp, near Elkins, Aug 4, 1985, RGT #850804/03.

Mating System: Heterothallic, bipolar. Six monokaryons of RGT #840722/02 were mated in all combinations and yielded 3 A1's and 3 A2's. Nine monokaryons of #840722/03 yielded 8 A1's and 1 A2. Four monokaryons of #830812/02 that would not form dikaryons amongst themselves, all formed dikaryons with both A1 and A2 of #840722/02.

Cultural Characters: Nematophagous; anamorph *Nematoctonus angustatus*.

Observations: This is by far the most common *Hohenbuehelia* in Ontario. Fruit bodies are persistent, and can be found readily by a search of suitable, brown-rotted logs any time during the late summer. In areas like Rondeau Provincial Park, Ontario, where such habitat is common, *H. angustata* can be locally abundant. *Hohenbuehelia angustata* is most readily recognised by its small, subglobose spores, but can be identified macroscopically in Ontario by its generally spathulate form and very crowded gills. This species is variable in outline, however, and ranges in colour from off-white when young through to warm brown in age, so that separate fruit bodies on a single log might be taken at first glance as representing more than one species.

Murrill (1916) recognised *Pleurotus stratosus* as this species, as did Coker (1944). Since Coker had a broad concept of *Pleurotus* that included this species, he had to use the combination *P. stratosus* because *angustatus* was occupied in *Pleurotus*. Authentic material of *Pleurotus stratosus* Atk. at TRTC was examined and found to be conspecific with *Hohenbuehelia angustata*, with spores 3-4 X 3.0-3.5 µm. The spore characters given in the original diagnosis ("oval to subglobose, 2-3 µm", Atkinson, 1902) are in error.

Pleurotus petaloides f. *americana* Pilat (1935) was based on a specimen from Ithaca, N.Y. (as was Atkinson's *P. stratosus*). It is also identical to *H. angustata*, as has been pointed out by Singer and Kuthan (1980). Its spores

were described as subspherical, 3.5-4.5 µm.

This fungus was described as *Pleurotus petaloides* Fr. by Peck (1886), who noted the crowded lamellae and globose spores 3-4 µm in diameter. Kauffman (1919) followed Peck, and because of this, many early records of *P. petaloides* in the Americas (eg. Bisby et al., 1929) were based on *H. angustata*.

Hohenbuehelia approximans (Peck) Singer (1951: 255) Fig. 17
= *Pleurotus approximans* Peck (1911: 37)
= *Resupinatus approximans* (Peck) Murrill, in Murrill, et al. (1915: 241)

Pileus dimidiate, sessile, attached dorsally or broadly along the base, 4-10 mm long X 4-12 mm broad (dry), youngest example dusky brown (5D4-3 to 5C3-2 in centre, paling to buffy (4A3) on margin (dry), very finely white hispid in the centre and glabrous at both base and margin. Older examples were straw-coloured (4A-B3-4), with medium brown base (5B3-D4) (dry), margin both pellucid and sulcate, edge entire. **Stipe** none. **Gills** radiating from point of attachment with one tier of lamellulae, narrow, moderately close, creamy white to pale yellow (4A2-3) (dry), about 1 mm deep. **Flesh** very thin. Dried fruit bodies are translucent. **Cuticle** thin, 15-25 µm, pale brown in KOH, with small fascicles of hyaline, cylindric, smooth, round-tipped hyphae 25-65 µm tall X 4-6 µm diam. Cuticular hyphae prostrate, 3-6 µm diam., smooth, but in places with pale amorphous-granular coating. **Gelatinous Zone** hyaline, 150-200 µm thick, of tangled hyphae (those near cuticle nearly parallel, those near trama zig-zag and obliquely rising) 1.5-4.0 µm diam. (most 3 µm). **Trama** pale brown in KOH, 150 µm deep; hyphae horizontal and parallel in upper zone, becoming tangled below and descending to form gill trama, 3-7 µm diam., with gelatinized walls up to 2.0 µm thick. **Gill Trama** parallel-interwoven, hyaline, hyphae similar to cap trama, all with clamps.**Basidia** 4-pronged, clavate-cylindric, hyaline, 25-30 X 6-7.5 µm. **Metuloids** broadly lanceolate, hyaline, faintly dextrinoid, with encrusted apices, (35) 42-70 X (9) 10-20 (25) µm. **Cheilocystidia** fusoid-ventricose, hyaline, 20-32 X 4-6 µm, including a neck (sometimes branched once) about 5 X 2-3 µm, and an hour-glass cell about 5 X 2-2.5 µm; mucous

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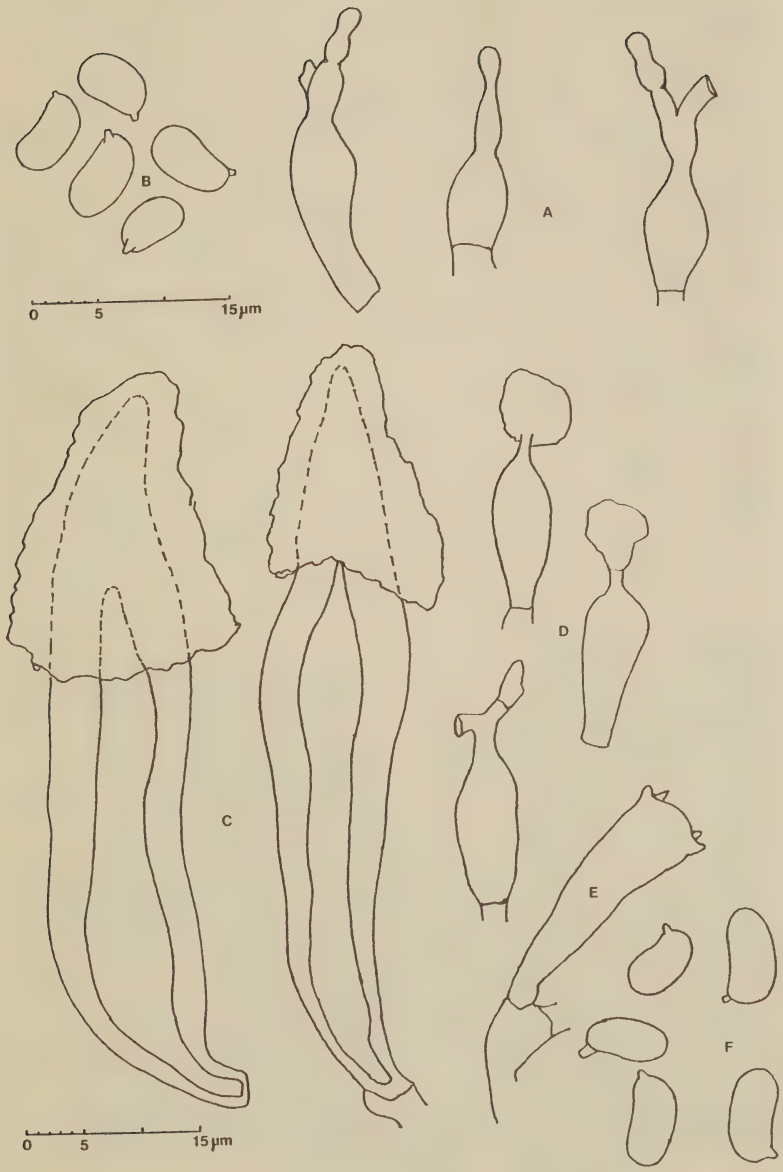
Figure 17 A-F: *Hohenbuehelia approximans*. A-B) DAOM #188324 (T-116). A) Cheilocystidia; B) basidiospores. C-F) DAOM #153672. C) Two metuloids; D) three cheilocystidia; E) a basdium; F) basidiospores.


B
A
0
5
15µm
C
D
E
F
0
5
15µm

ball, when present, 4-5 µm diam. **Spores** hyaline, inamyloid, smooth, elliptic-phaseoliform, (6.5) 7.0-8.1 X 3-4 (4.5) µm.
Habitat: On dead woody dicots.
Distribution: This species was described from New York (Peck 1911), and has been reported from North Carolina (Coker, 1944), Connecticut and Virginia (Miller, in press) in the United States, and is now known from New York, and southern Ontario in Canada.
Specimens Examined: Canada: Ontario: Eramosa Twp., Wellington Co., Nov. 17, 1984, R.G. Thorn #841117/01; Point Pelee National Park, Sept. 18, 1981, J.E. and S.A. Redhead, DAOM #188324; Thwartway Island, St. Lawrence Is. National Park, Sept. 12, 1975, S. Thomson, DAOM #153672. **United States: New York**: Orient, March 1, 1923, R. Latham, Dearness #5072 (at DAOM).
Mating System: Unknown.
Cultural Characters: Nematophagous; anamorph *Nematoctonus robustus*.
Observations: This species is obviously very close to the small forms of *Hohenbuehelia atrocaerulea* var. *grisea* that have been found in North America such as those described by Smith (1934). Smith's collections differed in their dark grey to black colouration from the straw colour or warm brown that seems typical and consistent in *H. approximans*. Singer (1951 a) and Miller (in press) have stated that *H. approximans* may be identical to *H. reniformis* (Meyer: Fr.) Singer. The description by Fries (1821) does not give enough information to refute this possibility, but the illustration authorised by Fries (Fries, 1874) and one by M.C. Cooke (1883) do not closely resemble *H. approximans*. The illustration in Fries' Icones shows *Agaricus* (*Pleurotus*) *reniformis* with a pale- to medium-brown cap, with spiky, black hairs, and tan-coloured gills. Cooke's illustration shows the cap as olive to khaki-brown, with coarse, dark tomentum, and olive-yellow gills. Pilát (1935) described the gills of *P. reniformis* as white or whitish, becoming grey, brownish or dark sooty, and mentioned that the walls of the metuloids are weakly to distinctly brown. A specimen from Japan (DAOM #187821) seemed to match this concept of *H. reniformis* closely, that is so different from *H. approximans* with its gills "nearly snow white,... becoming creamy when older" (Coker, 1944).

Hohenbuehelia atrocaerulea (Fr.) Sing. var. *grisea* (Peck) Thorn and Barron, **comb. nov.** Figs. 18 & 19
Basionym: *Pleurotus atrocaeruleus* (Fr.) Kummer var. *griseus* Peck (1891: 147)

= *Pleurotus griseus* (Peck) Peck (1909: 25)
= *Resupinatus griseus* (Peck) Murrill, in Murrill et al. (1915: 240)
= *Hohenbuehelia grisea* (Peck) Singer (1951 a: 255) [**non** *Hohenbuehelia grisea* (Massee) Horak (1980: 315)]

Pileus dimidiate, orbicular or conchate, up to about 3 cm long by 4 cm broad, margin downcurved to wavy; nearly glabrous and silky-shining toward margin to frosted, tomentose, or strigose toward base; margin not striate when fresh, hygrophanous, fading to off-white (4-5A2) or buffy (4A-B3, 5B3) from watery grey or olive brown (5C-D-E3-4, 6E4) or blackish brown (5-6F4-5) fading to deep brownish-grey (ca. 5D1-2), and becoming faintly striate on drying. Basal tomentum pallid, whitish to yellowish (4-5A2). **Stipe** rarely developed, amounting to no more than a small (1-3 mm long) semicircular sterile area at the base of the gills. **Gills** radiating from point of attachment, moderately narrow, close (2/ mm) or moderately well-spaced, pale yellowish white (3-4A2), drying concolourous or yellower (4A4), finely frosted under 10X. **Cuticle** a thin, pale or dark brown (KOH) zone of repent, tangled, brownish hyphae, (10) 15-25 (30) µm deep; hyphae thin-walled, with clamps, smooth or pigment-encrusted, (2) 3-6 (8) µm diam. **Epicutis** consisting of tufts of hyaline or yellowish tomentum hyphae up to 600 µm tall,

Figure 18: *Hohenbuehelia atrocaerulea* var. *grisea*, R.G. Thorn #840909/02, X 2.

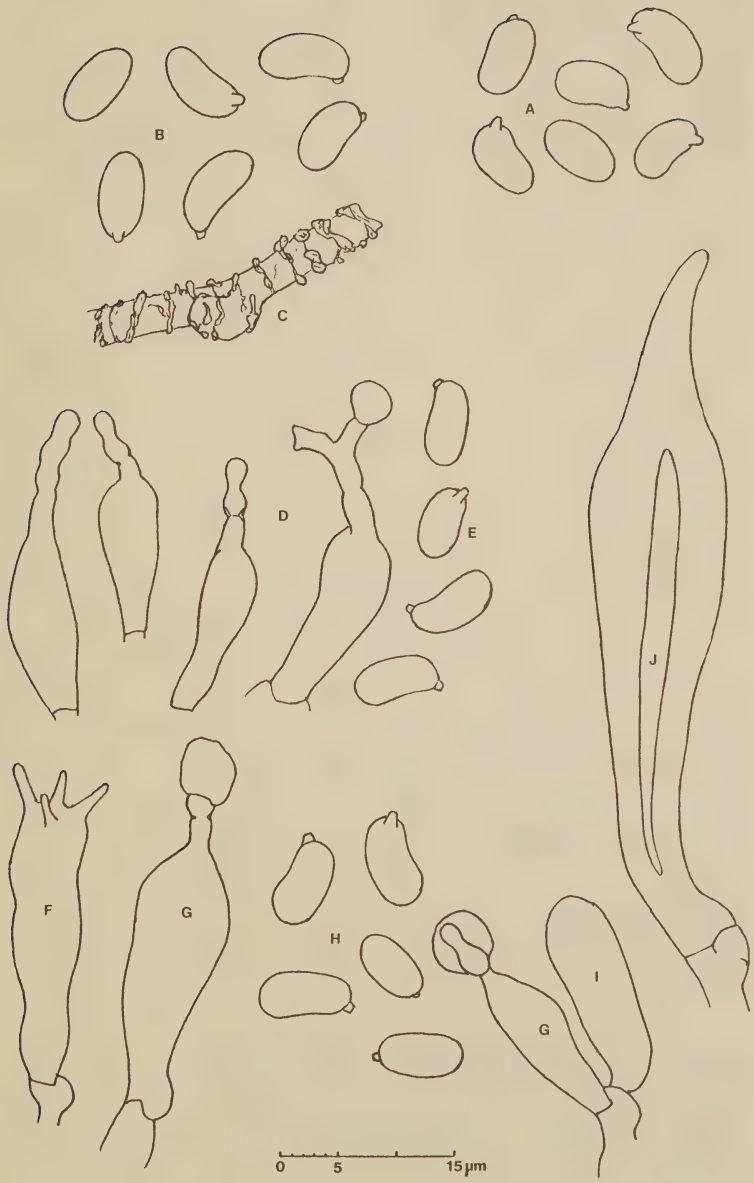
thin-walled or with walls up to 1.0 µm thick, smooth or encrusted, clamped and occasionally secondarily simple-septate, with rounded tips, 2-6 µm diam. **Gelatinous Zone** hyaline, commonly 150-250 µm deep, but up to 1000 um deep; hyphae hyaline, yellowish in Melzer's, mostly tangled-ascending, mostly smooth but often finely encrusted toward cuticle, 1.5-4.0 (6.0) µm diam., with clamps. **Trama** pale yellow-brown in KOH, deep golden yellow in Melzer's, a dense tangle of hyphae 2-5 (7) µm diam. with smooth walls gelatinized to 1.5 µm thick; descending into gills to form gill trama. **Gill Trama** hyaline or pale brownish yellow (KOH), parallel-interwoven, of hyphae 2.5-7 (12) µm diam., with walls gelatinized, commonly 0.5-2.0, up to 3.0 µm thick. **Subhymenium** hyaline, narrow, indistinct. **Hymenium** hyaline, 20-30 µm deep. **Basidia** (2-) 4- spored, hyaline, clavate, (20) 24-32 X 5-7 µm diam. **Cheilocystidia** lecythiform, clavate-rostrate, capitate, hyaline, (15) 19-30 X 5-7 (10) µm, neck usually short and tapering, 1-4 (7) X 2-3 um, hour-glass 4-5 X 1.5-2.0 µm, mucoid droplet 3-5 um diam. **Metuloids** hyaline or faintly yellow, lanceolate, encrusted in age, 27-105 X 7-26 µm, commonly 40-60 X 8-10 µm; walls up to 6.0 µm thick, pale brick red in Melzer's. **Spores** white in print, hyaline, inamyloid, smooth, elliptic-phaseoliform, typically (6.0) 6.5-8.5 (9.0) X (3.0) 3.2-4.2 (4.5) µm., but up to 11.0 X 4.4 µm in one specimen with predominantly 2-spored basidia (RGT #840713/01).

Habitat: *H. atrocaerulea* var. *grisea* occurs on both standing and fallen dead wood, almost always hardwoods, but DAOM #158848 occurred on *Juniperus*, and DAOM #58766 on *Pinus strobus*. The *Nematoctonus* state is commonly recovered from farmyard soil (Barron and Dierkes, 1977).

Distribution: Widely distributed in eastern North America and Europe, and reported (Singer and Digilio, 1953) from Argentina.

Selected Specimens Examined: **Canada**: **Nova Scotia**: Blomidon Provincial Park, Kings Co., September 1, 1985, R.G. Thorn #85009/07. **Ontario**: Almonte, Sept. 20, 1956, R. Horner, DAOM #59766; Bear Island, Lake Temagami, Sept. 4, 1934, H.S.

Figure 19 A-J: *Hohenbuehelia atrocaerulea* var. *grisea*. A) Basidiospores of Ellis and Everhart, Fungi Columbiani #1202 (TRTC). B-C) DAOM #64990. B) Basidiospores; C) an encrusted cuticular hypha. D-E) DAOM #48912. D) Four cheilocystidia; E) basidiospores. F-J) DAOM #158848. F) Basidium; G) cheilocystidia; H) basidiospores; I) basidiole; J) metuloids, with crystalline cap dissolved away.


A
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15 µm

Jackson, TRTC #7602; Bell's Corner's, Nov. 2, 1955, S. Gibson, DAOM #48912; Petawawa F.E.S., Aug. 29, 1943, J.W. Groves, DAOM #17383; Mallorytown Landing, St. Lawrence Is. Natl. Park, June 22, 1976, A. Carter, DAOM #158848; North Gower, July 26, 1955, M.E. Elliot, DAOM #54625; ex Guelph, N90 fruiting in culture, R.G. Thorn #840713/01. **Quebec**: Gatineau Park, July 26, 1961, K. Aoshima, DAOM #89037; Cantley, Sept. 9, 1984, RGT #840909/02. **United States: Indiana**: Bloomington, Aug. 15, 1981, R.E. Halling #3421 (FH). **Maine**: Belfast, Waldo Co., Oct. 1, 1972, R.L. Homola #5450 (MAINE). **Vermont**: Middlebury, Aug. 1896, E.A. Burt, Ellis & Everhart N. Amer. Fungi #3505 at TRTC; same locale, Aug. 1897, E.A. Burt, Ell. & Ev. Fungi Columbiani #1202 at TRTC. **Austria**: Vienna, "7-9-31", Litschauer & Lohwag, Fungi selecti exsiccati europei #143 at TRTC. **Czechoslovakia**: Silherovice, Moravia, July 26, 1974, R. Singer C5683 (F). **Sweden**: Sala, Västmanland, June 26, 1946, R. Morander, Flora Suecica s.n. at DAOM. **Australia**: Beermullah, 80 km north of Perth, Western Australia, June 19, 1983, M. Blackwell, UWA #2833.

Mating System: Heterothallic, bipolar (Barron and Dierkes, 1977 and this study).

Cultural Characters: Nematophagous; anamorph ***Nematoctonus robustus***. In 1947 ***Pleurotus griseus*** was reported to produce an antibiotic named pleurotin (Robbins et al, 1947). When the antibiotic was isolated, it was shown to form orange crystals that had a low solubility in water (0.125 mg/mL at 25% C). Its activity was temperature and pH sensitive. Later, Arigoni (1968) determined the structure and formula of pleurotin by x-ray crystallography (Figure 20 f). Robinson et al (1947) showed that pleurotin was active against gram positive bacteria, including ***Staphylococcus aureus*** and ***Bacillus subtilis***, but not gram negative bacteria such as ***Klebsiella pneumoniae*** or ***Escherichia coli***. Bauerle (1981) showed that pleurotin had only a very weak antibiotic effect under his lab conditions, even against gram positive bacteria. However, the importance of pleurotin to ***H. atrocaerulea*** var. ***grisea*** for substrate protection or self-

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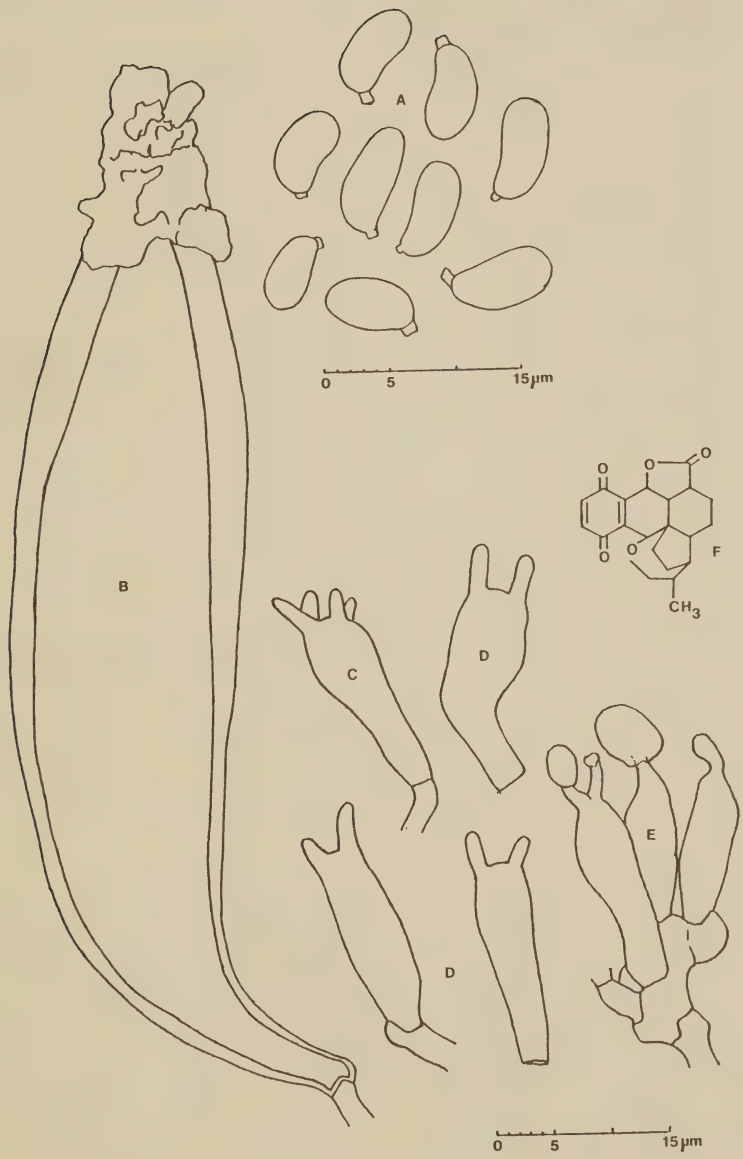
Figure 20 A-E: *Hohenbuehelia atrocaerulea* var. *grisea* ("N90"), RGT #840713/01 (= Barron #20 fruiting in culture). A) Basidiospores; B) a metuloid, beginning to develop a crystalline apex; C) 4-spored basidium; D) 2-spored basidia; E) cheilocystidia. F: Structural formula of pleurotin, $C_{21}H_{22}O_5$.


A
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CH3
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defence in the rich microbial environment where this species naturally occurs may be considerable.

Observations: This variety remains a taxonomic problem, as it has been since its description and before. Peck (1886), in writing a monograph of the New York species of *Pleurotus*, described it (as *P. atrocaeruleus* Fr.) as having a dark blue, blackish-grayish or tawny brown pileus, in deference to European descriptions of *P. atrocaeruleus*. He went on to say that, "I have seen no American specimens with the dark blue or indigo color shown in the published figures of the European plant, but Fries himself says that the pileus is sometimes brown, so that we have no doubt about the specific identity of our plant." The original description of *Agaricus atrocaeruleus* (Fries, 1821), however, simply read, "*pileo carnoso villoso atrocoeruleo, strato superiori gelatinoso, lamellis albidis*." The reference to brown colouration in *Agaricus atrocaeruleus* appeared only in later descriptions (Fries, 1838). Singer (1951 b) reported that the painting of *Agaricus atrocaeruleus* that Fries commissioned (but which was never published) showed the cap as dark blue.

Modern European descriptions of *H. atrocaerulea* (Pilat, 1935; Moser, 1983) commonly include brown in the range of cap colours. Although Singer (1951 a) at first questioned the distinctness of *H. atrocaerulea* and *H. grisea*, he has since kept them separate, and tried to clarify the situation by providing a redescription of *H. grisea* (Singer, 1977). In this paper Singer listed the distinctive characters of *H. atrocaerulea* as its dark blue-grey colour, ... , slightly narrower spores (2.7-4.3 µm versus 3.3-4.5 µm in *H. grisea*), and its encrusted tomentum hyphae. Later, Singer and Kuthan (1980) provided a key to the *H. atrocaerulea* group in which the key character was the encrusted tomentum hyphae of *H. grisea*, not *H. atrocaerulea*!

All of the specimens cited above are considered conspecific. Some were European collections identified as *H. atrocaerulea*, yet none showed any signs of blue colouration. One specimen (Ellis & Everhart, Fungi Columbiani No. 1202) was cited by Singer (1977) as typical of *H. grisea* and another (Singer C 5683), sent by Singer as *H. grisea*, was a companion specimen to another cited in the same paper. There is little doubt that we have Singer's *H. grisea*, and that it is the same as *H. atrocaerulea* to many others.

Reports of blue-black collections of *H. atrocaerulea* are infrequent but recurring (Christiansen, 1958; Miller, in press). Details of microscopic characters have been scanty, but the spores are sometimes reported as being larger than those of *H. grisea*. Those of a blue-black collection from

Denmark (Christiansen, 1958) were 8-10 X 4-5 µm, from 4-spored basidia. Singer and Kuthan (1980) have suggested that these large-spored forms possibly belong to *H. portegna* (Speg.) Sing., which was described from Argentina. The colours in this species range from brown (Spegazzini, 1881) to blue-black (Singer and Kuthan, 1980). According to Singer and Kuthan, the basidia are predominantly 2-spored, but also 1-, 3-, and 4-spored, with spores ranging from 8.5-11.8 (14.5) X 3.3-6.2 µm depending on the sterigmatal number. The anamorph of a specimen of *H. portegna* from Argentina is *Nematoctonus campylosporus*.

A further complication is *H. fluxilis* (Fr.) Orton. Orton (1964) redescribed the species as having a brown cap, 2-spored basidia, and spores (8) 8.5-10 X 3.5-4.5 µm. Fruiting bodies of N90 produced in culture may shed some light on this problem. Barron and Dierkes (1977) reported the fruit bodies of N90 as greyish-brown, and to have spores 5.5-8.8 X 3.2-4.8 µm on 4-spored basidia. A fructification of the same culture that was produced on cased sawdust in a growth cabinet (RGT #840713/01) had a deep brown cap (6E-F7), predominantly 2-spored basidia, and spores 6.5-9.4 (11.0) X (2.9) 3.5-4.4 µm. Interfertility tests between single spore cultures of these "species" should be conducted to determine which are good biological species, and which are varieties of one wide-ranging, polymorphic species. The combination of *Pleurotus griseus* Peck as a variety of *H. atrocaerulea* is proposed to distinguish the common, brownish forms of *H. atrocaerulea* (with small spores) from the apparently rare, but typical, blue-black forms that have larger spores.

The variable cheilocystidia of *H. atrocaerulea* sensu lato have also led to some confusion. Most often they have only one neck and cap, and the cap has a very distinct hour-glass secretory cell. Sometimes, however, the neck is branched 2 to 4 times. In squash mounts of gills or gill sections of old herbarium material, the hour-glass cells at the ends of the neck often collapse and only the branched (or unbranched) neck remains visible. This was the basis of *H. atrocaerulea* var. *dendrocystis* (M. Lange) Bon (Lange, 1955).

Hohenbuehelia cyphelliformis (Berk.) Miller, in Thorn (1986: 32)

= *Agaricus cyphelliformis* Berkeley (1837: 511)

= *Agaricus sylvanus* Saccardo (1877: 1)

Additional synonymy, plus a full description and illustrations are provided by Thorn (1986).

Fruit Bodies cupulate, pendant or conchate, 2-6 mm diam., dorsally or laterally attached, greyish brown to almost black (6D-F3), appearing glabrous and translucent-striate when fresh and moist (lines one unit darker), drying black, opaque, with fine white floccose bits or whisps over surface. Margin even or slightly wavy. **Gills** radiating from a near central point on underside, stark white, becomimg faintly greyish, usually narrow, distant. **Basidia** 4-spored, clavate, (21) 26-30 X 6.2-8 µm. **Cheilocystidia** fusoid-capitate, with well-formed or poorly formed hour-glass, occasionally branched, 18-38 X 4-7 µm, hour-glass 4-6.5 X 1.2-2.0 (2.5) µm, mucoid ball 5-8 µm diam. **Metuloids** clavate or fusoid, thin-walled (up to 0.5 µm thick), not projecting (resembling basidioles), pale brown in base (KOH), 21-40 X 4.5-7.0 µm, brilliant magenta in Cresyl Blue, apices entirely obscured by conical or ovoid crystalline masses 8-12 (16) µm diam. X 12-20 µm tall. **Spores** white in print, hyaline, inamyloid, smooth, broadly allantoid, (7.5) 8-10 (11.5) X 2.8-3.8 (4.2) µm.
Habitat: On dead twigs or stems of woody dicots.
Distribution: Found in Europe, North Africa, and northeastern North America (Thorn, 1986).
Specimens Examined: **Canada: Ontario**: Dennison Farm, Opeongo Lake, Algonquin Park, R.G. Thorn #841013/01 & #841013/11; Conc. #3 Eramosa Twp., Wellington Co., RGT #841117/02.
Italy: Selva, Treviso, Mar. 1877, PAD #3644 (type of *Agaricus sylvanus* Saccardo).
Mating System: Unknown.
Cultural Characters: Nematophagous; anamorph *Nematoctonus robustus*.
Observations: *Hohenbuehelia cyphelliformis* is readily recognised by the combination of its size, cupulate habit, stark white, distant gills, strongly curved spores, and its habitat. This species seems to require rich, undisturbed habitats. The old field in Algonquin where RGT #841013/01 and #841013/10 were collected had been abandoned since 1881, when the farmer was killed by a black bear.

Hohenbuehelia longipes (Boud.) Moser, in H. Gams (1967: 108)
= *Pleurotus longipes* Boudier (1905: 69)

Hohenbuehelia longipes was not encountered during this study. An excellent description of the only North American collection, with illustrations and full synonymy, was provided by Redhead (1978). The following description is adapted from Boudier (1905), Favre (1948), Kuehner et al. (1962) and Redhead (1978):

Pileus infundibuliform to spathulate, 1.5-3.5 cm broad, golden brown to sooty brown, glabrous. **Stipe** lateral or nearly central, 3-8 cm long, 2-5.5 mm wide, light brown. **Flesh** off-white, with farinaceous odour and taste. **Lamellae** decurrent, white to deep cream, narrow, close. **Basidia** typically bisporic, 30-35 (45) X 6-7.5 µm, but 4-spored in S.A. Redhead #2013 (DAOM), 22-25 X 6.5-7 µm. **Cheilocystidia** lecythiform, capitate, 17-33 X 4-8 µm, with or without hourglass cell 6.5-10.5 X 2.2-4 µm, surrounded by a mucoid droplet. **Metuloids** lanceolate, thick-walled, hyaline, apices encrusted, 70-110 X 8-14 µm. **Basidiospores** white, hyaline, inamyloid, smooth, elliptic-cylindric to slightly phaseoliform, 7-13 X 4-6 µm.
Habitat: Among mosses in mountain or northern bogs or fens. Redhead (1978) suggests that it may be calciphilic. If so, *H. longipes* might be looked for in Ontario in the boggy areas of the Bruce Peninsula or Manitoulin Island.
Distribution: *H. longipes* has been recorded from France, Germany and Switzerland, and from Quebec, Canada.
Mating System: Uncertain. Kuehner et al. (1962) suggested that *H. longipes* is amphithallic (= secondarily homothallic) and tetrapolar. This conclusion was based on their observation that one monokaryon was dikaryotised through the Buller phenomenon by each of about ten dikaryons. They reasoned that because all confrontations led to dikaryotisation, tetrapolarity was more likely, whereas the opposite is true. Basidiospores were found to have one to five nuclei, with 62% having three nuclei per spore.
Cultural Characters: The illustrations of Kuehner et al. (1962) strongly indicate that *H. longipes* is nematophagous. Conidia and what look like adhesive knobs with hour-glass secretory cells were produced on Hagem's and cassein hydrolysate media. The size and shape of the conidia would undoubtedly differ in culture with nematodes, but were reported to be narrowly fusoid, 10-18 X 2 µm. Hyphae were generally 2-3 µm diam., but sometimes inflated to 10 µm, with clamps. Adhesive knobs had a mucous ball of 9-11 µm diam., and the hour-glass cells that they illustrated were 7-8 X 2.5-3 µm, with the waist about 1.5 µm. Colony characters were not described.
Observations: *H. longipes* is readily recognised within the genus by its well-developed, often central stem, and its habitat. The one collection from North America differs from those described from Europe in its 4-spored basidia and smaller spores (7-9 X 4-5 µm, Redhead, 1978). Favre (1948) reported the basidia of his collection as 2-spored, and the spores as 9.5-11 X 4.8-5.5 µm. The collection reported by

Kuehner et al. (1962) was similarly bisporic, the spores "10-11 X 4-6 µm". However, in the Kuehner collection, 20.5% of the spores were reported to be uninucleate, with a mean length of 7.9 µm. Redhead (1978) noted that 2- and 4-spored races are recognised within other species in the Agaricales, and that this one character was not sufficient to recognise the North American collection as a new species.

H. longipes is certainly worth looking for and studying further, to determine its sexuality and confirm its nematophagous habit.

Hohenbuehelia mastrucata (Fr.: Fr.) Singer (1951: 255) Figs. 21 & 22

= *Agaricus mastrucatus* Fries (1818: 229)

= *Agaricus mastrucatus* Fr.: Fries (1821: 190)

= *Pleurotus mastrucatus* (Fr.: Fr.) Saccardo (1887: 376)

= *Geopetalum mastrucatum* (Fr.: Fr.) Kuehner and Romagnesi **nom. invalid.** (1953: 68)

Pileus dimidiate to flabelliform, sessile, 1.5-5.5 cm long, 2-4.5 (10) cm broad, and up to 0.8 cm thick. Surface moist, colour dark, watery brownish grey (near 6E3) or blue-grey (20E2-3), becoming paler to greyish buff (5C-D3 to 4A2); covered with thick, blunt, gelatinous spines, especially near margin; white-frosted with fine white tomentum towards the base. **Stipe** none, or occasionally a small sterile zone at the base of the gills. **Gills** radiating from point of attachment, narrow, close to moderately spaced, off-white, from greyish to pale buff (4B-A2 plus white); slightly frosted on margins. **Flesh** ranging from entirely gelatinous, grey-brown (watered down 5B3) and up to 3 mm thick, to primarily white-fleshy with a fine dark line (5F5) representing the gelatinous zone, the fleshy zone up to 3 mm thick. Taste bland, odour farinaceous. **Cuticle** only slightly differentiated from gelatinous zone, visible in Melzer's reagent as 5-10 µm deep, of repent, tangled hyphae (1.5) 2-4 (6) µm diam., mostly smooth, but some finely spiral-encrusted, loose ends on surface 2-3 µm diam., almost all capped with hour-glass secretory cells, 5-7 X 1.5-2.5 µm, mucoid droplet 6-8 µm diam. X 7-10 µm tall **Gelatinous Zone** more or less hyaline, total 400-450 µm thick; of 2 subzones; lower zone 150-250 µm deep, hyaline, of smooth ascendant (60-75 % above horizontal) hyphae 1.5-3.0 µm diam.; upper zone pale brown (golden in Melzer's), 100-200 µm deep, of horizontally-arranged hyphae, some finely encrusted. **Trama** commonly 200-400 µm thick (but up to 3 mm in some specimens), clay brown in KOH, of three subzones;

Figure 21: *Hohenbuehelia mastrucata*, R.G. Thorn #820902/12, X 1.25

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upper zone 40-60 µm deep, showing black inclusions under 10X objective), appearing tightly pseudoparenchymatous in tangential section, of nearly parallel, radially-arranged hyphae 2-4 (5) µm diam., dark brick-red in Melzer's; middle zone 75-150 µm thick that forms a separation layer when dry, very loosely tangled, hyphae mostly thin-walled, 2-5 (7) µm diam.; lower zone 100-150 µm thick, dense and tangled, greyish (KOH), orange-brown in Melzer's, descending to form gill trama, hyphae thin-walled, or slightly gelatinous-walled (up to 0.75 µm thick), (2) 4-7 µm diam. **Gill Trama** of hyaline, gelatinized, parallel-interwoven, hyphae, most 3-5 µm diam., some up to 10 µm diam. **Subhymenium** indistinct in KOH, deep brilliant orange in Melzer's, 20-40 µm thick. **Hymenium** about 30 µm thick, greyish brown in KOH, golden in Melzer's. **Basidia** 4-pronged, clavate-cylindric, hyaline, 24-36 (40) X 7-8.4 (9.0) µm. **Cheilocystidia** fusoid-ventricose to clavate-capitate, hyaline, 30-45 X 4.5-7.0 µm, the neck about 2.0-2.5 µm diam., sometimes branched once, the hour-glass well-formed, 6-8.5 X 3-4 µm, the waist (1.0) 1.2-1.6 (2.1) µm diam., the mucus, when present, about 6 um diam. **Metuloids** lanceolate, hyaline, becoming crystal-encrusted at their apices, (32) 44-90 (102) X 8-15 (17) µm. **Spores** white in print, hyaline, inamyloid, smooth, ovate, (6.5) 7-9

(10.5) X 4-5.5 (6.0) µm.
Habitat: On dead wood, almost always on hardwoods, but its *Nematoctonus* state was once isolated from heart rot in *Pinus strobus* (T-143). Ontario collections were on *Acer*, and one Quebec collection was on *Acer* and *Juglans*. The Algonquin collection was found in a rich, mature hardwood forest, in a soggy hollow of a large, fallen *Acer saccharum* log. The *Nematoctonus* state is far more common than the collections of fruiting bodies would suggest, and is often isolated from soil, in woods, lawns and farmyards.
Distribution: Rare, but found in northern Europe, eastern North America, and Japan (Murata, 1978).
Mating System: Unknown.
Cultural Characters: Nematophagous; anamorph *Nematoctonus hamatus*.
Specimens Examined: Canada: Ontario: Algonquin Provincial Park, West Gate, Sept. 2, 1982, R.G. Thorn #820902/12; same locale, Oct. 4, 1982, RGT #821004/03; Appin, Sept. 27, 1923, Dearness #5330 (at DAOM); Rondeau Provincial Park, Aug. 30, 1926, J. Dearness and G. Bell, Dearness #6175 (at DAOM); South March, S.C. Hoare, DAOM #40222. Also cultured fruit bodies from culture T-23 (Barron #167, ex Guelph area soil), RGT #840713/02. **Quebec**: Kingsmere, Gatineau Park, Sept. 27, 1954, DAOM #45328 (part also at TRTC). **United States: Maine**: Pushaw Lake Area, Old Town, Penobscot Co., Sept. 29, 1970, R.L. Homola #4066 (MAINE).
Observations: *Hohenbuehelia mastrucata* is readily recognised when fresh by its blue-grey to grey-brown, dimidiate pileus with squarrose gelatinous spines over its surface, particularly toward the margin. It is likely to be confused only with *H. atrocaerulea* var. *grisea*, which is glabrous to finely tomentose on the margin and finely to coarsely tomentose towards the base, and lacks gelatinous spines. Microscopically, the broadly elliptic to ovate spores distinguish *H. mastrucata* from *H. atrocaerulea* var. *grisea*, in which the spores are narrower and elliptic-phaseoliform. It is difficult to discern what fungus Pilát (1935) described under *P. valesiacus* (with *P. mastrucatus* as a questionable synynom); it may have been *H. mastrucata*, but he said that it was closest to *P. petaloides*, and had a

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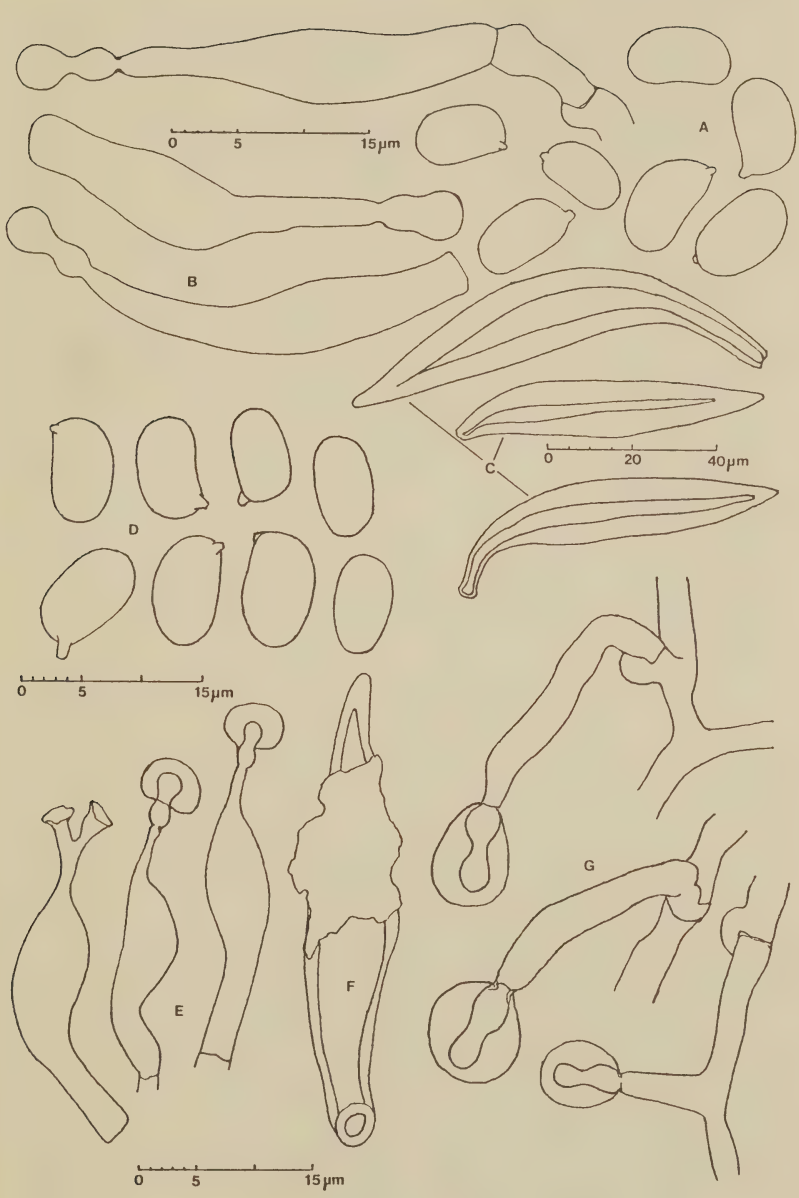
Figure 22 A-G: *Hohenbuehelia mastrucata*. A-C, and G) RGT #840713/02 (T-23 fruiting in culture). A) Basidiospores; B) cheiolocystidia; C) metuloids (at a reduced scale); G) pilocystidia. D-F) DAOM #45328. D) Basidiospores; E) cheilocystidia; F) metuloid.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whitish, hairy cap.

Hohenbuehelia mastrucata appears to be quite rare, probably because it is found fruiting only in very old, mature hardwood forests with undisturbed rotting logs.

Hohenbuehelia mustaliensis (Karsten) Thorn (1986: 61)
= *Agaricus mustaliensis* Karsten (1876: 99)
= *Phyllotus mustaliensis* (Karsten) Karsten (1879: 94)
= *Pleurotus mustaliensis* (Karsten) Saccardo (1887: 381)

Fruit Bodies flabelliform to orbicular, up to 7 mm broad and 7 mm long, sessile or with short pseudostipe; margin black and glabrous, with pebbly surface; disk tomentose with yellowish , brownish or black tomentum (disk of Fungi Fenniae #605 covered with deep mat of appressed, cottony basal mycelium). **Lamellae** radiating from point of attachment, narrow, moderately close to subdistant, cream to pale greyish yellow (4A2 to 4B3) when young (dry), becoming grey-brown (5D3) to black at maturity (dry), with whitish margins, finely frosted under 10X. **Cuticle** 15-30 µm thick, a repent tangle of hyphae (2) 3-8 µm diam. that are smooth or with amorphous or spiral bands of encrusting material. **Epicuticular Hyphae** hyaline to yellow-brown (KOH), up to 100 µm long X (2) 3-6 µm, with glassy walls to 1.5 µm thick, with hyaline, rounded apices. **Gelatinous Zone**: (150) 300-400 µm thick, hyaline or pale brown (KOH), hyphae zigzagging upwards, 2-4 µm diam., becoming golden brown and spiral-encrusted toward cuticle. **Trama** bilayered, with a dense, medium to dark brown (KOH) upper layer 50-70 (100) µm deep, of parallel, radial hyphae 2.5-6 µm diam., some coarsely encrusted; and a lower pale brown layer (50) 100-700 µm deep, more gelatinized, descending to form lamellar trama, hyphae (2) 3-6 (8) µm diam., with walls gelatinized to 1.5 µm thick. **Lamellar Trama** subhyaline, gelatinized, nearly parallel. **Subhymenium** indistinct, ca. 10 µm deep, paler than trama. **Basidia** 4-pronged, clavate, (21) 24-37 X 6-8 µm. **Cheilocystidia** fusoid-capitate to clavate-capitate, (18) 20-30 (34) X 5-7 (8) µm, sometimes branched at the apex, hour-glass cells 4-6 X 1.5-2.0 µm, mucoid droplet 5-7.5 µm diam. **Metuloids** lanceolate, at first hyaline, becoming brown-walled, often showing outer, and occasionally inner, hyaline layers, apices acute, becoming crystal-encrusted, 32-87 X 7-12 (15) µm. **Spores** hyaline, inamyloid, elliptic-phaseoliform, smooth, (6.8) 7.0-9.4 (10.4) X (3.5) 4.0-5.1 µm. All hyphae with clamp connections.

Habitat and Distribution: on bark of dead *Pinus sylvestris*

in Finland and *Pinus contorta* in Alberta, Canada.
Specimens Examined: Canada: Alberta: Strachan, Sept. 23, 1954, V.J. Nordin et al., DAOM #46374; same locale, Oct. 21, 1954, V.J. Nordin, DAOM #46785. **Finland**: Mustalia, Dec. 8, 1865, P.A. Karsten, Fungi Fenniae Exsiccati #605 (FH; isotype of *Agaricus mustaliensis*); same locale, Nov. 1877, P.A. Karsten, de Thümen's Mycotheca universalis #1003 (at DAOM).
Mating System: Unknown.
Cultural Characters: Unknown, except that basal mycelium of Fungi Fenniae #605 had hyaline, clamped hyphae (1.2) 1.8-5.0 µm diam., mostly thin-walled but with walls to 0.75 µm thick, and scattered hour-glass cells 4-5 X 1.5-1.8 µm, with mucoid balls 5-7.5 µm diam.
Observations: *Hohenbuehelia mustaliensis* is close to *H. nigra*, but is distinguished by its habitat and tomentose pileus. It is probably more common than records indicate, and might be expected to occur in Ontario on planted *Pinus sylvestris*, or on native *P. divaricata* or *P. resinosa*.

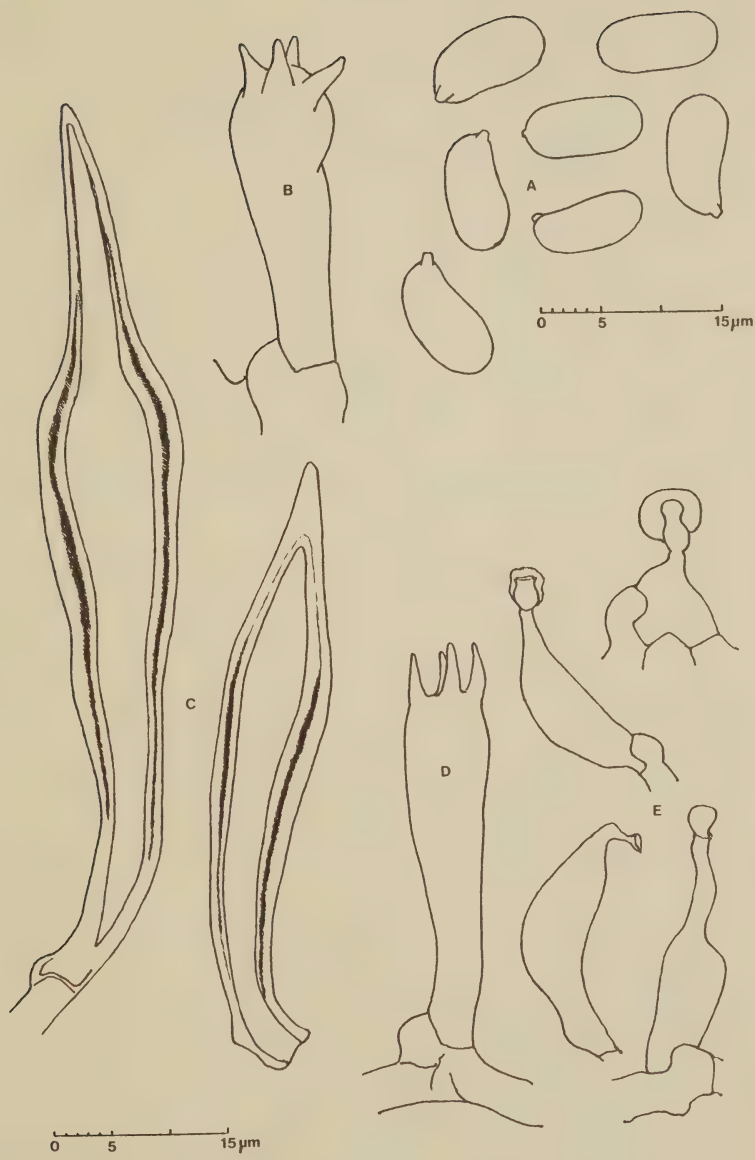
Hohenbuehelia nigra (Schw.) Singer (1951: 256) Fig. 23
= *Agaricus* (*Pleuropus*) *niger* Schweinitz (1822: 90)
= *Pleurotus niger* (Schw.) Saccardo (1887: 380)
= *Resupinatus niger* (Schw.) Murrill, in Murrill et al. (1915: 242)

No Ontario specimens were seen. Two collections from Dawson, Yukon Territory matched the original description (Schweinitz, 1822) and the description by Coker (1944), of two Scheinitz specimens, in all respects.
Pileus cupulate to conchate, up to 8 mm broad X 6 mm deep (as revived), dorsally attached, sessile or with brief pseudostipe, black, with olive brown (5E6) margin (as revived), not striate, glabrous except for a few scattered white hairs. **Lamellae** radiating from point of attachment, moderately narrow and close, dingy olive brown (5D4-5F5, as revived), markedly spiny under 10X. **Cuticle** dark brown in section (KOH), 10-15 µm thick,of encrusted, brown-walled hyphae with clamps, mostly repent and interwoven, 3-6 µm diam. **Gelatinous Zone** hyaline (in section in KOH), 300-600 µm thick (no cover-glass), of very loosely arranged, basically ascendent hyphae 1.5-3 µm diam., with conspicuous clamps and finely encrusted walls, becoming darker, more encrusted and broader (commonly 3-4, up to 5 µm diam.) near cuticle. **Cap Trama** pale brown in KOH, upper zone (50-75 µm thick) of horizontally (tangentially) arranged hyphae, below which they become tangled and descend into gill trama. Hyphae 3-5 (8) µm diam., with smooth, sometimes thickened

walls. **Gill Trama** pale brown in KOH, parallel-interwoven, hyphae (2) 4-7 (8) µm diam., some with walls up to 0.75 µm thick. **Subhymenium** indistinct 5-10 µm deep. **Hymenium** brown, darker than subhymenium or trama,, 25-37 µm deep, apices of hymenial elements often hyaline, since brown sap does not completely refill them on reviving. **Basidia** (2-) 4-pronged, clavate-cylindric, 28-38 X 6.5-8µm. **Cheilocystidia** abundant, variable, fusoid or clavate with drawn-out neck, 9-35 X 5-6 µm; neck 5-9 X 2-3 µm, hour-glass about 4 X 2.5 µm, mucous ball 5-6 um diam. **Metuloids** lanceolate, inner wall brown, extending 10-18 µm above hymenium, 33-75 X 8-12 (14) µm. **Spores** hyaline, inamyloid, elliptic-phaseoliform, smooth, (6.0) 7.5-10 (10.5) X 3.5-4.5 µm.
Habitat: on dead deciduous wood of *Juglans* (Schweinitz, 1822) and *Alnus* (Miller, in press).
Distribution: *Hohenbuehelia nigra* has been confused with many other species, among them *Resupinatus applicatus*, *R. trichotis* and *H. pinacearum*. Coker (1944) knew of only the Schweinitz collections. Miller (in press) reports it from Montana, Oregon, Pennsylvania and Virginia. Now known from the Yukon Territory, Canada.
Specimens Examined: Canada: Yukon Territory: Dawson, July 6, 1961, J. Holms, DAOM #89048 and DAOM #89049.
Mating System: Unknown.
Cultural Characters: A culture identified as *H. nigra* by O.K. Miller, Jr. (VT #1324) is nematophagous, with anamorph *Nematoctonus robustus*. Another culture, RLG #10761, identified by Miller as *H. niger* and received from the Forest Products Lab, Madison, Wisconsin, is not nematophagous (Thorn and Barron, 1984).
Observations: This species seems to be quite distinctive, with its jet black, almost glabrous, cupulate cap, dark gills, brown-walled, lanceolate metuloids, elliptic spores and its occurrence on hardwoods. It is rarely collected, but since the geographic range of known specimens spans Ontario, it is possibly to be expected here.

Hohenbuehelia nigra is a member of a group of species with small, dark basidiomes, dark gills and usually brown-walled metuloids, including *H. crustosa* (Coker) Singer (1951; nom. invalid.), *H. mustaliensis*, *H. pinacearum*, *H. subbarbata* (Berk. & Curt.) Singer (1951), and *H.*

Figure 23 A-E: Hohenbuehelia nigra. *A-B) DAOM #89048. A) Basidiospores (at a slightly larger scale); B) a basidium. C-E) DAOM #89049. C) Metuloids, showing dark brown middle layer of tri-layered walls; D) basidium; E) cheilocystidia.*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unguicularis. This group appears to be closest to the genus *Resupinatus*, notably *R. alboniger*.

Hohenbuehelia petalodes (Bull.: Fr.) Schulzer, in Schulzer et al. (1866: 45) Fig. 24
= *Agaricus petalodes* Bulliard (1785: 226) [**non** *A. petaloides* Sommerfeldt (1826: 258)]
= *Agaricus petaloides* Bull.: Fries (1821: 183)
= *Pleurotus petaloides* (Bull.: Fr.) Quélet (1872: 226)
= *Geopetalum petaloides* (Bull.: Fr.) Patouillard (1887: 127)
= *Acanthocystis petaloides* (Bull.: Fr.) Kuehner (1926: 111)
= *Agaricus spathulatus* Persoon (1801: 479)
= *Agaricus petaloides* Bull.: Fr. var. *spathulatus* (Pers.: Fr.) Fries (1821: 183)
= *Pleurotus spathulatus* (Pers.: Fr.) Peck (1886: 63)
= *Agaricus geogenius* de Candolle ex Fries (1838: 134)
= *Pleurotus geogenius* (DC. ex Fr.) Quélet (1886: 149)
= *Geopetalum geogenium* (DC. ex Fr.) Patouillard (1887: 127)
= *Acanthocystis geogenia* (DC. ex Fr.) Kuehner (1926: 111)
= *Hohenbuehelia geogenia* (DC. ex Fr.) Singer (1951: 255)

Fruit Bodies petaloid (semiinfundibuliform), 3-7 cm tall X 2-5 cm broad, relatively fleshy; surface beige (4-5A3) to grey-brown (6E3-6), glabrous near margin to finely pruinose then white-tomentose toward base; margin not striate, somewhat wavy or inrolled. **Stipe** a pseudostipe, continuous with cap, upper surface often canaliculate, lower surface whitish, matte or tomentose. **Gills** decurrent, narrow or very narrow, close or crowded, shallow, whitish when fresh (notes with DAOM #180790) to pale cream (4A2) or yellow-ochre (4A5 + brown) when dry. **Flesh** white. **Cuticle** poorly differentiated, pale to medium brown (KOH), 10-15 µm deep, of tangled repent hyphae 2-5 µm diam., with loose, vertical, hyaline hyphae 10-40 µm tall, sometimes tipped with hour-glass cells 4-6 X 1.5-2.5 µm, which are usually without mucoid ball. **Dermatometuloids** inconspicuous but sometimes numerous, woven among cuticular hyphae, acicular, pale brown, 42-101 X 5-8 µm, solid or with lumen of 1-3 µm diam. **Gelatinous Zone** hyaline, 100-300 µm deep, of tangled horizontal and predominantly ascendant hyphae 2-3 (5) µm

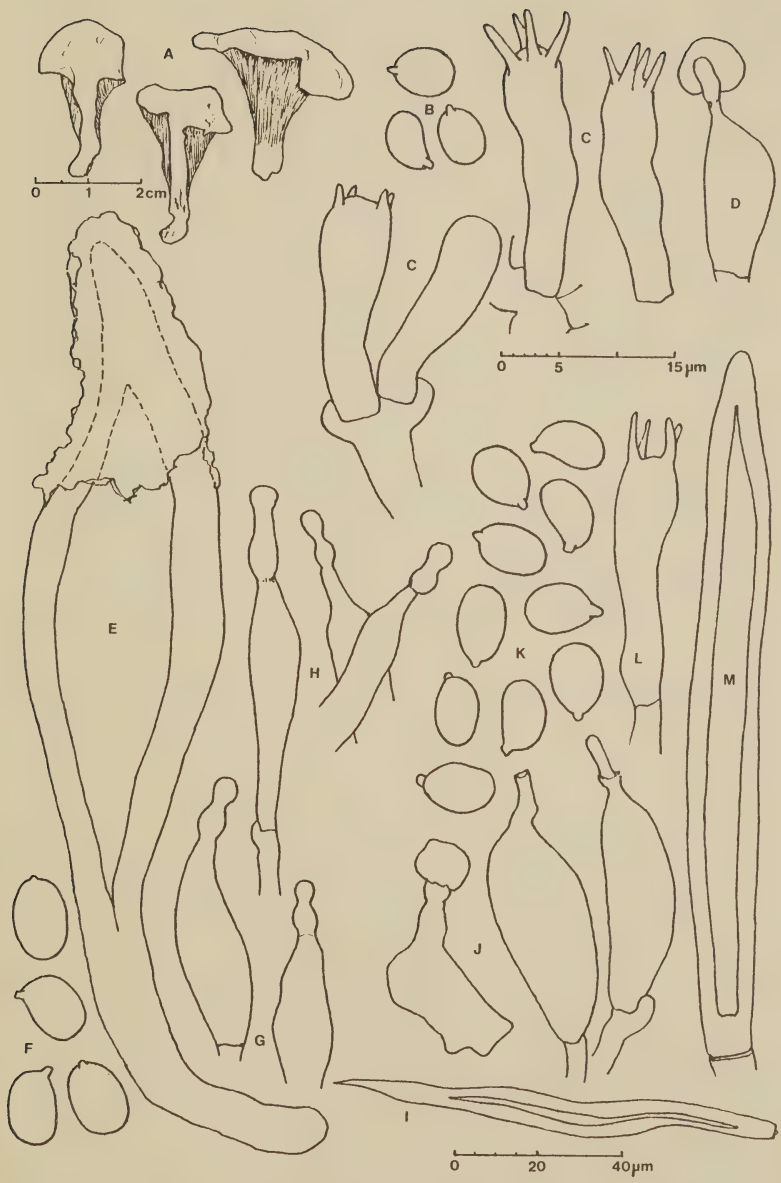
diam., with clamps. **Trama** consisting of two layers: an upper, pigmented zone 70-100 µm deep of compact, parallel hyphae 3-5 µm diam., then a deep (0.7 to 3 mm thick) hyaline context of tangled hyphae 3-6 (10) µm diam., continuous with the gill trama. **Basidia** 4-pronged, hyaline, clavate, (20) 24-36 X 5.5-8 µm. **Cheilocystidia** fusoid-ventricose or lecythiform, capitate, 16-35 X 4.5-8 µm, sometimes branched, hour-glass cells 5-7 X 2-3 µm. **Metuloids** lanceolate, hyaline or yellowish (KOH), (45) 54-92 (100) X 8-17 (20) µm, encrusted in age with a conical cap of crystals. **Spores** white in print, hyaline, inamyloid, smooth, elliptic to subglobose, (5) 5.5-7.5 (9.0) X (3.0) 3.5-4.5 (5.2) µm.
Habitat: On soil in lawns, planting beds, or with potted plants, often associated with woody debris.
Distribution: Widely distributed in Europe (Pilat, 1935), North America (Coker, 1944; Miller and Manning, 1976), and reported from Venezuela (Dennis, 1970), New Zealand (Horak, 1971) and Japan (Murata, 1979).
Specimens Examined: **Canada: British Columbia**: Brentwood Bay, Vancouver Is., Mar. 18, 1984, A. Funk, DAVP #22978; Lulu Island, Sept. 10, 1966, M.A. Waugh, DAOM #115345. **Nova Scotia**: Kentville, July 21, 1961, K.A. Harrison, DAOM #113630; **Ontario**: Ottawa, Sept. 28, 1981, A. Hamilton, DAOM #180790. **Quebec**: Knowlton, Brome Co., Aug. 22, 1974, H.W. Johnston, DAOM #148928; Quebec City, Aug. 1, 1967, M. & Mme. R. Cauchon, DAOM #127429. **United States: California**: Sacramento, Aug. 22, 1984, B.L. Thompson #411 (USC). **Maine**: University of Maine, Orono, Aug. 6, 1973, R.L. Homola #A5558 (MAINE). **Maryland**: Baltimore, July 20, 1985, W. Sullivan, R.G. Thorn #850803/01. **New York**: Ithaca cemetary, July 27, 1903, H.S. Jackson #677 (at TRTC). **Tennessee**: Anderson Co., Sept. 26, 1943, Flora of Tennessee s.n. (at TRTC); Knoxville, Oct. 8, 1936, Fl. Tenn. #9546 (at TRTC). **Sweden**: Dlr. Falun: Hemskogsvagen, Sept. 25, 1983, R. Morander, Fungi Suecici #4656.
Mating System: Unknown.
Cultural Characters: Nematophagous; anamorph *Nematoctonus geogenius*.
Observations: *Hohenbuehelia petalodes* is readily recognized by its petaloid, fleshy fruit bodies that occur on soil in lawns or cultivated areas, and its short-elliptic spores. Bulliard (1792) made the following statement, which has since proven ironic: "*Rapproch. On ne peut confondre cette espece avec aucune autre*". *Hohenbuehelia petalodes* has, however, been confused with several other species. Fries (1821) cited Bulliard's plates in his description of *Agaricus petaloides*, but the fungus he described is a

different species that occurs in Europe, on hardwood logs. This other species is the same one described under the names *Geopetalum petaloides* by Kuehner and Romagnesi (1953), and *Hohenbuehelia petaloides* by Singer (Singer and Kuthan, 1980). Bulliard's concept of *Agaricus petalodes* has priority, however, and is the one for which the name must be used. *Hohenbuehelia petaloides* sensu Kuehner, Romagnesi, and Singer is spathulate, thin-fleshed, and has a shallow gelatinous zone of horizontally-arranged hyphae. The most appropriate name for this species may be *Hohenbuehelia auriscalpium* (R. Maire) Singer. Fries (1838) later described *Agaricus geogenius*, based on correspondence with A.P. de Candolle. Fries noted that this species differed only slightly from *A. petaloides*, and it is clear from the description that *Agaricus geogenius* DC. ex Fries (1838) refers to *Agaricus petalodes* Bulliard (1785). Fries (1821) also added an "i" to *petalodes*, but there seems to be no reason not to accept Bulliard's original spelling.

Peck (1886) believed that the fungus now known as *Hohenbuehelia angustata* was the species that Fries (1821) had described as *A. petaloides*. This was a logical conclusion, since the macroscopic features (all that Fries described) of *H. angustata* and *H. auriscalpium* are quite similar. Peck described the true *H. petalodes* under the name *Pleurotus spathulatus*. Kauffman (1919) follwed Peck's treatment of these two species, although he also included *H. angustata* as *Panus angustatus*. The papers by Peck (1886) and Kauffman (1919) led to a number of reports of *H. "petaloides"* in North America (eg. Bisby et al., 1929) which are actually *H. angustata*.

In Europe, both *H. petalodes* (= *H. geogenia*) and *H. auriscalpium* (= *H. petaloides* sensu Singer) have been confused with *H. tremula* (= *H. rickenii* nom. invalid.). Redhead (1984) pointed out that the name *Agaricus tremulus* Schaeffer (1774) had been misapplied, and might represent the earliest available epithet for *H. rickenii*. Fries (1838) believed that part of Schaeffer's illustration of *A.*

Figure 24 A-M: *Hohenbuehelia petalodes*. A) R.L. Homola #A5558, habit of fruit bodies. B-D) DAOM #127429. B) Basidiospores; C) basidia and a basidiole; D) a cheilocystidium. E-I) DAOM #180790, E) A metuloid; F) basidiospores; G) cheilocystidia; H) pilocystidia; I) a dermatometuloid (at a reduced scale). J-M DAOM #113630. J) Cheilocystidia; K) basidiospores; L) a basidium; M) a dermatometuloid.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tremulus represented *A. tremulus* sensu Fries (= *Arrhenia acerosa* fide Redhead, 1984), whereas Schaeffer's figures 1 and 2 represented *A. petaloides* sensu Fries (*H. auriscalpium*). Bulliard (1792) cited *Agaricus tremulus* Schaeffer as a questionable synonym of *A. petalodes*. Schaeffer (1774), in turn, had cited *Agaricum infundibulum dimidiatum imitans* of Micheli (1729) as a synonym of *A. tremulus*, and Micheli's species is clearly *A. petalodes* of Bulliard (1785). However, from Schaeffer's description and illustrations, it seems that Redhead's interpretation of *A. tremulus* is correct. *Hohenbuehelia tremula* differs from *H. petalodes* in its occurrence in mossy coniferous woods, dark brown colouration, and long-elliptic spores, 7.5-9 X 4-5 µm.

Two collections from Japan (Kokoge, Tottori-shi, Sept. 2, 1981, E. Nagasawa, TOTTORI s.n.; and same locale, Sept. 25, 1981, T. Hongo and E. Nagasawa, TOTTORI s.n.) do not conform to the above description, nor to that of any described species. These have thin-fleshed basidiomes with a gelatinous zone 75-170 µm deep, of entirely vertical hyphae, but have the same short-elliptic spores as *H. petalodes* (5.8-7.5 X 3.8-4.8 µm). The anamorph of the first collection has plumper conidia and hyphal adhesive knobs than most isolates of *Nematoctonus geogenius*, but is nonetheless identified as that form-species. These two collections are perhaps closest to *H. recedens* Singer and Kuthan (1980), but differ in deeper gelatinous zone and longer spores.

Although the spores of *H. petalodes* are typically plump and short-elliptic, some collections have variable spores, some of which are elliptic-phaseoliform and reach 9 µm in length.

Hohenbuehelia pinacearum Thorn (1986: 37)

Thorn (1986) provided a full description, illustrations and an account of names misapplied to this species. **Fruit Bodies** cupulate to conchate or flabelliform, sessile or pendant from a short pseudostipe, 0.4-0.9 cm diam., surface moist and mostly glabrous when fresh, black or blue-black (20F4), with a few scattered white wisps particularly toward the margin; margin incurved, even or becoming wavy, not striate. **Gills** radiating from point of attachment or a central or excentric point on underside; at first silver-grey (B1), becoming deep olive-brown (4-5F4) to black or blue-black (20F4); moderately narrow, subdistant. **Basidia** (2-) 4-spored, clavate, hyaline, (22) 25-32 X 6-7.5 µm. **Cheilocystidia** fusoid or flexuous-cylindric, capitate or not, 22-45 X 4-8 µm, with 1 or 2 hour-glass cells 5-8 X 2-3 µm. **Metuloids** deep-seated, lanceolate or flexuous-cylindric,

hyaline, 37-50 X 6-8 µm, with walls up to 2.0 µm thick, except at the apex where they are thin-walled and collapsing, magenta in Cresyl Blue, capped with a conical mound of hyaline crystalline material. **Spores** white in print, hyaline, inamyloid, smooth, narrowly elliptic-phaseoliform, (6.0) 6.5-8.5 (9.0) X (2.5) 3.0-3.5 (3.8) µm from 4-spored collections; 7.5-10.5 (11.0) X 4.4-5.5 (5.7) µm from 2-spored Peck collection.
Habitat: On bark of conifers, both on dead, standing trunks and fallen logs and branches.
Distribution: Known from western Europe and northeastern North America (Thorn, 1986).
Specimens Examined: Canada: New Brunswick: Kouchibouguac National Park, May 16, 1977, R. Millikin, DAOM #165824. **Ontario**: Algonquin Provincial Park, Wolf Howl Pond, Oct. 15, 1983, R.G. Thorn #831015/04; Maple, May 5, 1936, J.W. Groves, TRTC #9470; Petawawa, Sept. 6, 1943, J.W. and E. Groves, DAOM #11428; Petawawa, Sept. 20, 1945, J.W. Groves, DAOM #16436; Lake Temagami, July 18, 1938, R.F. Cain, TRTC #13200, **holotype** (isotypes as DAOM #50083 and 80600). **Quebec**: Perce, Aug. 14, 1959, W.B., V.G. & S. Cooke, DAOM #84313. **United States: New York**: Bennetts [Adirondack Mountains], C.H. Peck s.n., [1884] (in NYS). **France**: Chansaye, Rhône, Jan. 3, 1933, M. Josserand XII/10, herb. Josserand.
Mating System: Unknown.
Cultural Characters: Nematophagous; anamorph *Nematoctonus brevisporus*.
Observations: This species may be macroscopically indistinguishable from *H. nigra* except by habitat, unless the projecting metuloids of the latter species can be seen under a magnifying lens. *Hohenbuehelia pinacearum* is characterised by its jet black, nearly glabrous pileus that is cupulate to conchate in form, its dark gills, inconspicuous metuloids, and occurrence on conifers. *Resupinatus alboniger* can be distinguished by its complete lack of both metuloids, and cheilocystidia or pilocystidia with hour-glass secretory cells.

Hohenbuehelia pinacearum has long been misidentified as *Pleurotus silvanus* (Sacc.) Saccardo (1887), by Josserand (1933), Pilát (1935), and Krieglsteiner (1979); as *Pleurotus atropellitus* Peck (1886) by Murrill (Murrill et al., 1915) and many collectors (in herb.); and as *Pleurotus unguicularis* (Fr.) Quélet by Coker (1944) and Miller and Manning (1976). This species is well illustrated by Konrad and Maublanc (1937: 309 II; as *Acanthocystis silvanus*) and Coker (1944: pl. 42, lower; as *Pleurotus unguicularis*).

Hohenbuehelia tremula (Schaeffer: Fr.) Thorn and Barron, **comb. nov.** Figure 25

Basionym: *Agaricus tremulus* Schaeffer (1774: 54) [illustrated, without name, in Schaeffer (1771: pl. 224)]

= *Agaricus tremulus* Schaeffer: Fries (1821: 191) [**not** sensu Fries]

Numerous nomenclatorial synonyms of *A. tremulus* Schaeffer: Fries refer to the species to which Fries misapplied the name, *Arrhenia acerosa* (Fr.) Kuehner (1980).

= *Geopetalum Rickenii* Kuehner **nom. invalid**, in Kuehner and Romagnesi (1953: 70)

= *Geopetalum Rickenii* Kuehner **nom. invalid**, in Kuehner and Romagnesi (1954: 74)

= *Hohenbuehelia Rickenii* Kuehner **nom. invalid**, in Kuehner and Romagnesi (1954: 75) ["alternative name"]

= *Pleurotus Rickenii* Kuehner **nom. invalid**, in Kuehner and Romagnesi (1954: 76) ["alternative name"]

= *Hohenbuehelia rickenii* Kuehner ex Orton **nom. invalid** (1960: 176)

= *Hohenbuehelia rickenii* Kuehner ex Donoso **nom. invalid.** (1981: 157)

The following description is based on dried herbarium specimens:

Fruit Bodies spathulate to petaloid, 2-5 cm long X 1-3 cm broad, medium (oak) brown to dark (date) brown, hoary-canescent over basal area and pseudostipe. **Gills** decurrent, yellow-ochre or buffy, narrow, moderately close, frosted with metuloids. **Cuticle** thin, about 10 um thick, brownish or subhyaline, poorly differentiated from gelatinous zone, of repent, interwoven, smooth hyphae with intracellular pigment, 2-6 µm diam., often with abundant loose ends terminating in well-formed hour-glass cells 6-12 X 2-4 µm, sometimes with mucoid droplet 5-10 µm diam. **Gelatinous Zone** hyaline, or with pale brown hyphae in clear matrix, 40-75 (150) µm thick, of tangled, obliquely rising (45-60 % above horizontal), smooth hyphae 1.5-4.0 (7) µm diam. **Trama** consisting of first a dense, deeply pigmented zone 50-75 µm thick, of parallel or nearly parallel hyphae, then a paler brown zone 400-500 µm thick, of densely interwoven hyphae 2-5 µm diam. **Gill Trama** subhyaline, parallel-interwoven, hyphae similar to those of cap trama, with some inflated to 15 µm diam. **Subhymenium** hyaline, about 10 µm thick. **Hymenium** hyaline, 25-30 µm thick. **Basidia** 4-pronged, hyaline, clavate, 18-26 X 6-7.5 (8) µm. **Cheilocystidia** lecythiform,

or fusoid-ventricose, capitate, (18) 24-37 X 4-7 µm, hour-glass 6-9 X 2.5-4.0 µm, commonly without mucoid ball, which when present are elliptical to spherical, 6-10 µm tall X 4-7 µm diam. **Metuloids** hyaline, lanceolate, encrusted in age, (45) 50-90 (115) X 10-16 (25) µm. **Spores** white in print, hyaline, inamyloid, smooth, elliptic-phaseoliform, (7.0) 7.5-9.0 (9.5) X (3.5) 4.0-5.0 (5.5) µm.
Habitat: on peaty soil or well-rotted wood, often among mosses, in coniferous forests.
Distribution: *Agaricus tremulus* was described from southern Germany (Schaeffer, 1771; 1774), and *Hohenbuehelia rickenii* was described from the French Alps, and reported from Britain by Dennis et al. (1960). Bresadola (1928) illustrates what appears to be this species, from Italy, and cultures under this name were sent by M. Semerdzieva from Czechoslovakia.
Specimens Examined: Canada: Northwest Territories: Fort Simpson, June 2, 1955, W.J. Cody and J.M. Matte, DAOM #51088. **Ontario**: Glen Major, June 7, 1936, G.S. Bell, TRTC #9488 (parts as DAOM #50122). Quebec: La Verendrye Park, July 9, 1958, M. Pantidou, DAOM #62813; Parc Laurentides, Aug. 15, 1981, D. Lahaie et al., DAOM #180808 (**neotype**). **United States: Michigan**: Douglas Lake, June 30, 1951, S.C. Hoare, DAOM #26937.
Mating System: Unknown
Cultural Characters: Nematophagous. Cultures of *H. rickenii* from M. Semerdzieva (of which the voucher specimens were not seen) matched the characters of the mycelium in the substrate of a number of the specimens cited above, and are thus accepted as identical. Anamorph *Nematoctonus geogenius*.
Observations: *Hohenbuehelia tremula* provides a classic example of nomenclatorial and taxonomic confusion. *Agaricus tremulus* (Schaeffer, 1774) was described as follows, "*Agaricus caulescens, solitarius, gelatinoso-coriaceus; pileo concavo, saepe deformi, dimidiati, lacero, cinereo-fusco* ..." Schaeffer cited *Agaricum infundibulum dimidiatum imitans* (Micheli, 1729) as a synonym. Micheli's species has the form and description of *Hohenbuehelia petalodes*. The illustrations of *A. tremulus* (Schaeffer, 1771, pl. 224, fig I-VIII) show the fungus to be blackish-brown, spathulate to petaloid, with a lateral stem, and growing among mosses. Schaeffer's plate 224, figure IX shows a white spore print on black paper; it must be in error, as it is radially symmetrical, and shows a central stipe. The globose spores shown in figure X may also be misplaced, or simply a result of the optics of the day. Somehow, Fries (1821) came to apply the name of this blackish-brown, tough-gelatinous

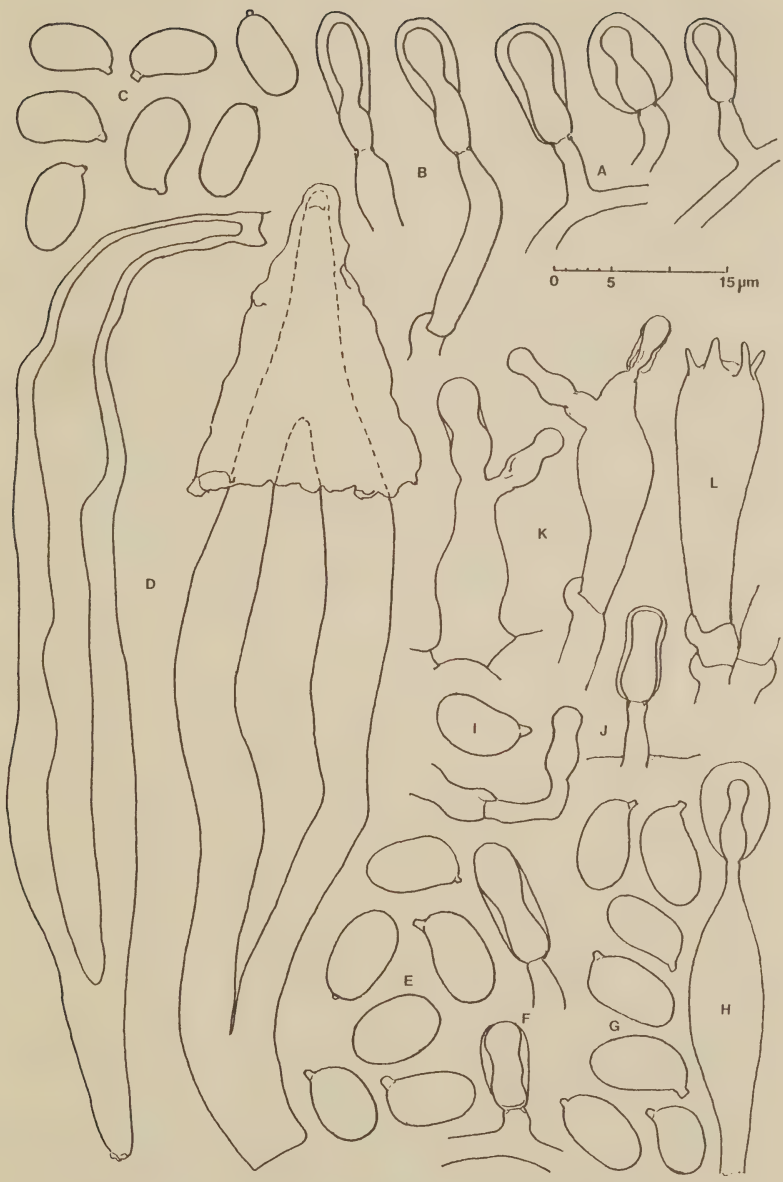
agaric to a greyish muscigenous species with thin, fragile flesh [*Arrhenia acerosa* (Fr.) Kuehner]. Most subsequent authors (Quelet, 1872; Rea, 1922; Pilat, 1935; Coker, 1944) followed Fries (1821) in this misapplication of *A. tremulus* Schaeffer. Redhead (1985) studied the genera *Arrhenia* and *Rimbachia* and pointed out that the name *A. tremulus* Schaeffer had been misapplied, and probably referred to *H. rickenii*, nom. invalid.

Ricken (1915) illustrated *Pleurotus geogenius* (= *H. petalodes*), showing the typical petaloid habit and short, ovate spores of that species. Kuehner (in Kuehner and Romagnesi, 1953) considered Ricken's fungus too dark to be *P. geogenius* and so redescribed it as a new species in honour of Ricken, but based on Kuehner's specimens. *Geopetalum rickenii* Kuehner (1953) is not validly published because it lacked a Latin diagnosis. No type specimen was designated, but this was not a requirement of valid publication until 1958. The spore size of Kuehner's fungus does not even overlap that given by Ricken. Singer and Kuthan (1980) recognised this and so described *H. recedens* (from Mexico), which they suggested might be Ricken's *P. geogenius*, but which instead is a third, different fungus.

Despite the confusion over the origin of the name, *G. rickenii* was well described, particularly in the "validating" publication (Kuehner, 1954) that supplied a Latin description. Unfortunately, no type specimen was designated, and the simultaneous publication of two alternative generic names made *G. rickenii* Kuehner (1954) invalid as well. Orton (1960) and Donoso (1981) both attempted to validate the name once again, but did not designate a type, so their combinations are also invalid.

Still, *H. tremula* is readily recognised by its flabelliform to petaloid habit, dark brown colours, long spores, and its occurrence in mossy coniferous forests. An excellent illustration of this species can be found in Bresadola (1928, plate 292, as *P. geogenius*), who reports it from "sylvis coniferis", with spores 8-9 X 4-4.5 µm.

Figure 25 A-L: *Hohenbuehelia tremula* A-D: DAOM #180808 (neotype). A) Predatory adhesive knobs on basal mycelium; B) pilocystidia; C) basidiospores; D) metuloids, one with crystalline cap dissolved away. E-F) DAOM 51088. E) basidiospores; F) predatory adhesive knobs from basal mycelium. G-H) TRTC #9488. G) Basidiospores; H) a cheilocystidium; I-L DAOM #26937. I) Basidiospores; J) pilocystidia; K) cheilocystidia; L) a basidium.


A
B
C
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0
5
15 µm

In order to provide a solid basis for this long-confused taxon, a neotype is proposed herein: DAOM #180808, near Lac Grandpre, Parc Laurentides, Quebec, Canada, Aug. 15, 1981, D. Lahaie et al. This collection was seen in the fresh condition by the senior author and matches in all respects the original (Latin) description of ***Agaricus tremulus*** Schaeffer (1774), and of ***Geopetalum rickenii***, nom. invalid. (Kuehner and Romagnesi, 1953).

Hohenbuehelia unguicularis (Fr.) Miller, in Thorn (1986: 43)
= ***Agaricus unguicularis*** Fries (1828: 24)
= ***Pleurotus unguicularis*** (Fr.) Kummer (1871: 104)
= ***Pleurotus atrocaeruleus*** (Fr.) Kummer var. ***minimus*** Dearness & Bisby, in Bisby, et al. (1929: 104)
Full synonymy, descriptions and illustrations are provided by Thorn (1986).

Fruit Bodies cupulate or conchate, pendent from an excentric dorsal or lateral pseudostipe, up to 6 mm diam., margin medium warm brown or slightly olive-brown (5-6E3-4; as revived), faintly striate in some, disk pruinose to densely strigose with white to buffy (4A2) hairs; when dry-silver grey (B1) to brownish-black (6E3+) or black, glabrous only where weathered. **Lamellae** radiating from a point on underside, moderately narrow, subdistant, warm grey-brown (6E3; as revived), grey-brown to black when dry, finely frosted under 10X, margin entire. **Basidia** 4-pronged, clavate, (22) 25-32 X 5.5-7.5 µm. **Cheilocystidia** clavate or fusoid-ventricose, 22-37 X 4-8 µm, with 1 or 2 hour-glass cells 5-9 X 2.5-4 µm, mucoid balls 4-6 µm diam., sometimes coalescing over gill edge. **Metuloids** clavate or fusoid with rounded, often collapsing apices, dark brown and with walls thickened to 1.5 µm from base to middle, thin-walled and hyaline at apex; scarcely projecting, but with conical cap of hyaline or yellowish crystalline material 8-12 µm diam. (looking down on hymenium), 20-60 X 6-10 µm. Walls deep purple in cresyl blue. **Spores** white in print, hyaline, inamyloid, smooth, narrowly elliptic-phaseoliform, (5.0) 6.0-8.5 (9.0) X 3.0-4.0 µm.

Habitat: On dead trunks and branches of hardwoods, with or without bark.

Distribution: Known from northern and western Europe, and northern North America (Thorn, 1986).

Specimens Examined: Canada: Manitoba: Victoria Beach, June 2, 1928, G.R. Bisby [#3906] et al., Dearness #6654 (holotype of ***Pleurotus atrocaeruleus*** var. ***minimus***, at DAOM). **Nova Scotia**: Highland Village, Colchester Co., June 17, 1954, A.G. Davidson, DAOM #46746. **Ontario**: Black Sturgeon Lake,

Thunder Bay District, June 11, 1976, S.A. Redhead, DAOM #159734; Dorset, Haliburton Co., May 28, 1963, R.F. Cain, TRTC #40707; Lobo, Nov. 8, 1931, J. Dearness #734 (at DAOM). **Quebec**: Cantley, Gatineau Co., Apr. 28, 1985, J. Ginns, DAOM #191960; Tenaga, May 1939, J. Groves and I. Mounce, DAOM #6998. **Yukon Territory**: Haines Junction, Aug. 2, 1962, J. Holms, DAOM #93025. **United States: New York**: Knowersville [now Altamont, Helderberg Mountains], Oct. [no year], C.H. Peck s.n. (NYS); Star Lake, Sept. 7, 1974, J. Ginns, DAOM #155519.

Mating System: Unknown.

Cultural Characters: Nematophagous; anamorph *Nematoctonus brevisporus*.

Observations: *Hohenbuehelia unguicularis* can be recognised by its dark, cupulate to flabelliform basidiomes with pale tomentum on the rear portion or apex, which may be drawn out into a pseudostipe, and by its lamellae that are silvery or pale tan when young and become dark in age. The peculiar, clavate metuloids, which are brown in their lower portions and hyaline and thin-walled at their apices, are diagnostic. An unusual feature of this species is that it fruits in spring or early summer, or in warm periods during winter (Gillet, 1876). Konrad and Maublanc (1937: pl. 309 III) illustrated *H. unguicularis* well, as *Acanthocystis Leightonii*.

RESUPINATUS C. Nees ex S.F. Gray (1821: 617)

Type species (only original species): *R. applicatus* (Batsch: Fr.) S.F. Gray

= *Phyllotus* Karsten (1879: xiv) [**not** *Phyllota* Bentham, in Endlicher et al. (1837: 33)]. Type species, selected by Singer and Smith (1946) and also obligatory under Article 7.11 of the I.C.B.N. (Voss, et al., 1983): *P. applicatus* (Batsch: Fr.) Karsten

= *Calathinus* Quélet (1886: 46) [**not** *Calathinus* Rafinesque (1838: 21)]. Type species, obligatory under Article 7.11: *C. applicatus* (Batsch: Fr.) Quélet. (Earle, 1909, selected *C. porrigens* (Pers.: Fr.) Quélet, but this is inadmissable.)

= *Scytinotopsis* Singer **nom. nud.** (1936: 355) Type species, obligatory under Article 7.11: *S. applicatus* (Batsch: Fr.) Singer.

The following generic description is paraphrased from Singer (1975), with additional delimiting characters added on the basis of this study:

Small (0.1–2.0 cm diam.), sessile or laterally pseudostipitate, pleurotoid or cupulate fruit bodies with well-developed or reduced (but present) gills; gills radiating from point of attachment or a central or excentric point on the underside of the cap; veil none; monomitic, but a gelatinous zone usually present in the flesh, often directly beneath the cuticle; hyphae of other zones of the trama sometimes with gelatinized walls; all hyphae inamyloid and with clamp connections; epicutis consisting of a rameales structure, of coralloid-diverticulate hyphae, often with thick, brown walls, and secreting what becomes a yellowish to brownish, solid, amorphous or crystalline encrusting material from branch-tips; thus the cuticle pigmented and often heavily encrusted; spores white in mass, hyaline, inamyloid, acyanophilic, globose, elliptic or phaseoliform; basidia normal; metuloids none; pleurocystidia none; cheilocystidia clavate, clavate-rostrate or fusoid, commonly diverticulate and forming a rameales structure on the sterile and often gelatinized gill edge; hymenophoral trama regular, but hyphae often interwoven. On rotting wood or herbaceous plants, rarely on living plants; the gills facing downwards. Heterothallic, tetrapolar; without a *Nematoctonus* asexual state; hyphae in culture often with fine palmate-digitate terminal branchlets.

The concept of *Resupinatus*, in Miller (in press), and with which we agree, is considerably restricted from that currently in use (Singer, 1975; Moser, 1983). Therefore the generic description has been amended to include only the type species, *R. applicatus*, and those that are unquestionably closely related. The diagnostic features of *Resupinatus* sensu stricto are the pigmented, gelatinized cap and the diverticulate cheilocystidia and cuticular hyphae. *Hohenbuehelia* differs from *Resupinatus* in the possession of hymenial metuloids, gloeosphex cystidia, and *Nematoctonus* anamorphs. The lack of a *Nematoctonus* state or nematophagous habit in *Resupinatus* supports this distinction.

Miller (in press) has transferred *R. cyphelliformis*, *R. sylvanus* sensu Coker, and *R. unguicularis* sensu Coker to *Hohenbuehelia*. Miller's transfer of *R. cyphelliformis* and *R. unguicularis* sensu Coker (= *Hohenbuehelia pinacearum*) appears well-founded: both have *Nematoctonus* anamorphs, as do all other species of *Hohenbuehelia* tested to date. *Resupinatus silvanus* sensu Coker has no *Nematoctonus* state, and does not have clearly-defined gloeosphex cystidia, either in material that I have studied or in the descriptions and illustrations of Miller (in press).

Resupinatus could be confused with several other genera

with more or less gelatinized, pleurotoid fruit bodies, namely *Marasmiellus, Campanella* and *Panellus*. Species of *Marasmiellus* with gelatinized cap tissues have definite, excentric stipes and are usually pale, and thus differ from the pigmented *Resupinatus* species, which at most develop a lateral pseudostipe that is continuous with the cap. Species of *Campanella* are also usually colourless, and have strongly anastomosing gills that often become poroid or honey-combed and reticulate. Species of *Panellus* have amyloid spores. Many features of the anatomy of *Panellus stipticus* (Bull.: Fr.) Karsten, the type species of *Panellus*, are similar to those of *Resupinatus* sensu stricto, including gelatinized gill edges with a rameales structure formed by diverticulate cheilocystidia, partly gelatinized trama, and diverticulate cuticular hyphae. The hyphae of *Panellus stipticus*, however, lack brown encrusting pigments, and its spores are small and elliptic to somewhat allantoid. *Panellus ringens* and certain allied species are brownish and have a more strongly gelatinized upper zone in the cap. *Panellus patellarilis* (Fr.) Konrad and Maublanc was found during this study to be tetrapolar and non-nematophagous. The relationship of these two genera requires further study, but for now *Resupinatus* seems more closely allied to *Hohenbuehelia* than to *Panellus*.

Stigmatolemma and *Stromatocyphella* are cyphelloid agarics clearly derived from *Resupinatus* sensu stricto. The coralloid-diverticulate cuticular hyphae of the two genera are similar to those found in *Resupinatus*, and their flesh is gelatinized. *Resupinatus kavinii* (Pilat) Moser (1978) of Europe seems to have evolved toward the cyphelloid habit. Its fruit bodies are cupulate and 1-3 mm diam., with up to 10 shallow lamellae. The oblong spores of *Stromatocyphella conglobata* are another reason for accepting the elliptic-spored *R. alboniger* in *Resupinatus* along with *R. applicatus* and other spherical-spored species.

Pleurotus vetlinianus Domanski (1964) has been transferred to *Resupinatus* by Moser (1979), but can not be accommodated in either *Resupinatus* sensu stricto or sensu lato, nor in *Hohenbuehelia*. It was described as being up to 15 cm long by 9 cm broad, thick-fleshed, with gelatinized gill trama and lower cap trama, and with thick-walled, simple-septate hyphae (possibly secondarily septate) interspersed with thin-walled, clamped hyphae in the trama. Its true taxonomic affinities are unknown.

Resupinatus alboniger (Pat.) Singer (1978: 17)
= *Pleurotus alboniger* Patouillard (1893: 126)
A full description, with illustrations and synonymy,

are provided by Thorn (1986).
Fruit Bodies cupulate to flabelliform, sessile, up to 6 mm broad, at first white-woolly or pruinose, becoming grey-brown to black and predominantly glabrous as this wears away. **Lamellae** radiating from point of attachment, narrow, subdistant, grey-brown to black, often with whitish margins. **Basidia** 4-pronged, clavate-cylindric, 18-25 X 5-7 µm. **Cheilocystidia** variable, fusoid, clavate, lecythiform or pyriform, with or without irregular digitate projections, 11-25 X (3.5) 5-11 µm, most thin-walled, one with walls near apex 2.0 µm thick. **Spores** hyaline, inamyloid, smooth, elliptic-phaseoliform, to cylindric and slightly curved, 5.8-7.8 X 2.7-3.6 µm.
Habitat: on dead woody dicots.
Distribution: Known from the southern and eastern United States, France, Ecuador, Venezuela and Tanzania (Thorn, 1986).
Specimens Examined: United States: Maine: Harrison, Sept. 1859, Burt #141 (FH). **Mississippi**: Ocean Springs, Feb. 1887, F.S. Earle, Ellis and Everhart's North American Fungi #2008 (at DAOM). Without source data, VT 1364 (from O.K. Miller, Jr., VPI) fruiting in culture, RGT #840810/01. **Ecuador**: Ravine near Quito, Feb. 1, 1982, Lagerheim s.n. (FH; **holotype** of *Pleurotus alboniger* Patouillard); Cotocollao, Feb. 1892, Lagerheim #87, NY (paratype). **Holland**: Veere, winter, 1830, M.A. Libert, Plantae cryptogamicae Arduennae #19-B (*ad ramos putridos Ribis grossulariae*), at DAOM. **Venezuela**: near Los Venados, El Avila, July 24, 1972, K. Dumont et al., VE 5872 (NY); near Manacal, NW of Irapa, July 9, 1972, K. Dumont et al., VE 4430 (NY).
Mating System: Heterothallic, tetrapolar. Of six single spore isolates of RGT #840810/01, three were A1B1, and one each was A1B2, A2B1, and A2B2.
Cultural Characters: Nematode negative, conidia none, neither in pure culture (PDA, MEA) nor on WA with nematodes.
Observations: *Resupinatus alboniger* can be recognized by its small, dark, sessile basidiomes that occur on woody dicots, its lack of metuloids, elliptic spores, and the presence of diverticulate cheilocystidia and diverticulate cuticular hyphae with thick, brown walls. The cheilocystidia of this species are variable and, in addition to the diverticulate ones, some collections have cheilocystidia that are fusoid, or broadly pyriform. This is the fungus described and illustrated by Coker (1944) as *Pleurotus silvanus*.

Resupinatus alboniger is similar in many ways to the small, dark species of *Hohenbuehelia*, but its diverticulate cheilocystidia and cuticular hyphae, and lack of a

Nematoctonus anamorph or metuloids show that it is correctly placed in *Resupinatus*, with the spherical-spored species such as *R. applicatus*.

Resupinatus applicatus (Batsch: Fr.) S.F. Gray (1821: 617)
Fig. 26
= *Agaricus applicatus* Batsch (1786: 171)
= *Agaricus applicatus* Batsch: Fries (1821: 192)
= *Pleurotus applicatus* (Batsch: Fr.) Kummer (1871: 105)
= *Phyllotus applicatus* (Batsch: Fr.) Karsten (1879: 94)
= *Calathinus applicatus* (Batsch: Fr.) Quélet (1886: 47)
= *Geopetalum striatulum* (Pers.: Fr.) Kuehner & Romagnesi, nom. invalid., var. *applicatum* (Batsch: Fr.) Kuehner and Romagnesi **nom. invalid.** (1953: 68)
= *Hohenbuehelia applicata* (Batsch: Fr.) Zerov and Peresipkin **nom. invalid.** (1979: 115)

Pileus cupulate, 3-5 mm diam., becoming spathulate or flabelliform with a lateral pseudostipe, 7-15 mm long X 5-15 mm broad, pseudostipe 2-5 mm broad, margin glabrous to pruinose, chocolate-brown (7F6) to black when wet, not striate or translucent striate, ash-grey (ca. C1) and nonstriate when dry; basal 1/3 to 2/3 covered with shaggy, stiff, coarse tomentum, especially dense over pseudostipe, pale greyish buff to brownish grey (4-5B2 but paler). **Gills** decurrent and radiating from pseudostipe, dark brown (6E3-4) when revived, moderately narrow and close, margins whitish and entire. **Flesh** gelatinous and black in mass. **Cuticle** dark brown in KOH, 20-30 µm thick, of densely woven brown, thick-walled, heavily encrusted hyphae 4-6 µm diam., with irregular or finger-like projections, apparently secreting what becomes the granular yellowish encrustation. **Epicutis** of hyaline, smooth tomentum hyphae, walls 0.5-0.75 µm thick, non-gelatinized, tips rounded and thin-walled, up to 200 µm tall, 2.0-4.0 µm diam. (most 3.0 µm), with clamps. **Gelatinous Zone** 150-300 µm deep in KOH (without cover-glass) subhyaline, with pale brown, smooth, clamped hyphae 2.0-5.0 µm diam. (most 3 µm) widely dispersed in hyaline gel. **Pileus Trama** medium brown in KOH, 30-50 µm deep, of densely woven hyphae 2.5-5 µm diam. **Gill Trama** continuous with that of pileus, medium brown in KOH, very irregularly interwoven of hyphae 2-5 um diam., some with walls gelatinized to 1.0 µm thick. **Subhymenium** dark brown in KOH, 15-25 µm thick, densely woven. **Hymenium** subhyaline, pale brown in KOH, 20-25

µm thick. **Basidia** 4-pronged, clavate, hyaline or faintly brown in KOH, (18) 22-25 (30) X 5-6 µm. **Cheilocystidia** numerous, more or less clavate, with coarse and fine finger-like projections, some with fine droplets at their tips (1 µm or less diam.), 14-25 X 5-7 µm. **Spores** hyaline, inamyloid, smooth, subglobose or globose, some with prominent apiculus, (4.0) 4.4-6.0 X 4.0-4.8 µm.
Habitat: On bark and wood of fallen hardwoods. Reports in the literature of its occurrence on conifers invariably refer to *R. striatulus* (q.v.).
Distribution: Apparently worldwide, although badly confused with *R. striatulus*.
Specimens Examined: Canada: Nova Scotia: Kentville, King's Co., Apr. 26, 1953, K.A. Harrison, ACAD #7596. **Ontario**: Brant Co., New Durham, Oct. 13, 1963, TRTC #41202 (part as DAOM #115047); York Co., Nashville, Sept. 26, 1953, TRTC #24926; same locale, Oct. 11, 1953, TRTC # 24972; Toronto, Hogg's Hollow, Oct. 12, 1931, TRTC #2736. **Quebec**: Gatineau Park, Ridge Rd., Oct. 17, 1956, DAOM #54231. **United States: Indiana**: Brown County Park, Aug. 1958, W.B. Cooke, ACAD #7603 **Maine**: Harrison, Aug. 1859, G. Blake, BUF #43356. **New Jersey**: Newfield, Nov. 1901, Ellis & Everhart, Fungi Columbiani s.n., at TRTC and DAOM. **New York**: Fort Edward, n.d., E.C. Howe s.n., Peck Herbarium (NYS; **lectotype** of *Pleurotus atropellitus* Peck); Maryland, Otsego Co., [Spet. 1876], Peck s.n., Peck Herbarium (NYS; as *P. atropellitus*). **Tennessee**: Oliver Springs, Oct. 25, 1936, L.R. Hesler, Flora Tennessee #9649 (at TRTC).
Mating System: Unknown for *R. applicatus* sensu stricto.
Cultural Characters: Nematode negative. Conidia none, neither in pure cultures (PDA, MEA) nor with nematodes on WA. Kuehner et al. (1962) report conidia in *R. applicatus* sensu Josserand (= sensu stricto), but this seems questionable and may refer to *R. applicatus* in the sense of Quélet (Kuehner, 1926), which is *Hohenbuehelia pinacearum*. In culture on WA with nematodes, aerial hyphae produce remarkable knobbed cells (Fig. 26 G) that look like "jacks". These are firmly attached by a stout (1.5- 2.0 µm

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Figure 26 A-G: *Resupinatus applicatus*. A-D) DAOM #54231. A) Three diverticulate cheilocystidia; B) a basidium; C) habit of fruiting bodies; D) basidiospores. E-F) TRTC #41202. E) Diverticulate cuticular hyphae; F) tomentum hyphae. G) T-99 (DAOM #54231), jack-shaped cells on aerial hyphae in culture on WA with nematodes.

0
1.0cm
C
0
cm
0.5
B
A
D
E
F
0
5
15 µm
G
G

diam.) peg with a clamp connection at the base of the cell, but are sometimes broken loose in a squash mount. These specialised cells are thin-walled, and are often observed to be empty, without cytoplasm, and are thus presumed not to be resistant spores (aleuriospores, or chlamydospores). These cells are thought to have their function in the capture of some unknown prey. Aleurioconidia of similar appearance occur in ***Microstella pluvioriens*** Ando & Tubaki (1984), which was isolated from rainwater collected from ***Metasequoia glyptostroboides*** Hu & Cheng in Japan.

Observations: ***R. applicatus*** sensu lato is very common in Ontario, as elsewhere, but by far the majority of the collections examined matched the description of ***R. striatulus*** and not ***R. applicatus*** as it was originally described by Batsch (1786) or Fries (1821). The distinctive features of ***R. applicatus*** sensu stricto are the conchate to flabelliform pileus that often reaches 1 cm, and occasionally 2 cm, from base to margin, with a felty, greyish tomentum over the back of the cap surface, leaving only a narrow glabrous or pruinose margin. Fries particularly emphasised this latter character, saying, "***pileo ... pruinato, basi villoso obscure cinerato***." ***Resupinatus striatulus***, in contrast, is smaller, cupulate, and pruinose overall, with at most whitish hairs at the point of attachment (basal mycelium). The possibility remains that these are only varieties of the same species, a possibility that could not be tested because no single-spore cultures from a collection of ***R. applicatus*** sensu Batsch were available. Until mating tests are done, it is perhaps best to clearly describe the variability that is encountered under appropriate, existing epithets. The distinctive "jack"-shaped cells of ***R. applicatus*** were not found in cultures of ***R. striatulus***.

Resupinatus applicatus sensu stricto apparently always occurs on fallen hardwoods. Coker (1944) tried to make the habitat distinction very neat by saying that ***R. striatulus*** always occurred on conifers. This is contrary to Fries (1821), who listed the habitat of ***Agaricus striatulus*** as "***ad lignea pinea, ramos Coryli, Betulae, etc***." and also contrary to the morphological variation observed among examples occurring on hardwoods. Many collections from hardwoods are cupulate, pruinose, and lack cap tomentum, and single spore isolates of one such collection (RGT #840910/03) were interfertile with those from a collection of ***R. striatulus*** from ***Pinus strobus*** (RGT #840808/09).

Resupinatus striatulus (Pers.: Fr.) Murrill, in Murrill et al., (1915: 242)
= *Agaricus striatulus* Persoon (1801: 485)
= *Agaricus striatulus* Pers.: Fries (1821: 193)
= *Pleurotus striatulus* (Pers.: Fr.) Kummer (1871: 105)
= *Phyllotus striatulus* (Pers.: Fr.) Karsten (1879: 94)
= *Calathinus striatulus* (Pers.: Fr.) Quélet (1886: 48)
= *Geopetalum striatulum* (Pers.: Fr.) Kuehner & Romagnesi **nom. invalid.** (1953: 68)

Fruit Bodies cupulate, sessile, dorsally or laterally attached, 1.5-7 mm diam., beige (4A2-B3), pinkish brown (6C-D3), grey-brown (5C2-3-D3) to blackish, darkening on drying; finely pruinose overall, or margin glabrous, appearing moist and polished when water-soaked; margin translucent-striate or not, sometimes faintly sulcate, edge entire or crisped. **Gills** radiating from point of attachment or a central or eccentric point on underside, moderately narrow to moderately thick, subdistant, concolourous with cap or slightly paler, buffy (4A2), pinkish-buff (5B2) or brown (5-6D3); margins paler, entire; surface glabrous or atomate. **Cuticle** 10-25 µm deep, a tangle of brownish hyphae, with many details obscured by heavy encrustations of yellowish granular or crystalline material. Hyphae 1.5-5.5 µm diam., with irregular knobs, branchlets, and pegs in some areas dense and repent, in other with loose ends verging on a trichoderm. **Gelatinous Zone** ca. 100 µm deep in cap margins, to 400 µm deep in centre, hyaline, with tangled and ascendent, faintly brownish hyphae, (1.0) 1.5-3.0 µm diam., clamps to 7 µm diam. **Trama** 45-150 µm deep, sometimes poorly distinguished from gelatinous zone, but usually more dense, pale brown, then descending into gills where it becomes more hyaline and gelatinised; hyphae 2-6 µm diam. **Gill Trama** extending to gill edges, making them gelatinised, hyphae 2-4 µm diam. **Subhymenium** medium to dark brown (KOH), 5-12 µm deep, hyphae becoming gelatinised and amorphous. **Hymenium** brown, often paler than subhymenium, 18-25 µm deep. **Basidia** 4-pronged, clavate, 20-27 X 5.5-7 µm. **Cheilocystidia** a dense fringe on gill edges, clavate-diverticulate, (10) 15-27 X 4-8 µm, projections tapering and needle-like, often tipped with a fine droplet 1.0-1.5 µm diam. and obscured by granular-crystalline yellowish encrusting material. **Spores** white in print, hyaline, inamyloid, globose or subglobose, (3.3) 4.0-6.0 X (3.1) 3.5-5.0 µm.

Habitat: On rotting coniferous or deciduous logs, usually

having a soft white rot. Most often found on the undersides of logs.
Distribution: Probably widespread in Europe and North America, confused in the literature with *R. applicatus*.
Selected Specimens Examined: Canada: British Columbia: Cowichan Lake, June 21, 1948, W.G. Ziller, DAOM #21617; Yellow Point, July 27, 1938, I. Mounce, DAOM #9172. **Manitoba**: W. Hawk Lake, near Ontario boundary, Aug. 29, 1936, G.R. Bisby, DAOM #7347. **New Brunswick**: Kouchibouguac National Park, July 28, 1978, K. Egger and R.A. Shoemaker, DAOM #170071. **Ontario**: Algonquin Provincial Park, Swan Lake, Oct. 7, 1954, S. Gibson and A. Hill, DAOM #46775; Algonquin Park, West Gate, Sept 22, 1982, R.G. Thorn #80922/06; same locale, Sept. 10, 1984, RGT #840910/03; same locale, Sept. 15, 1984, RGT #840915/03; Algonquin Park, Minkey Lake, July 28, 1984, RGT #840728/03; Hindon Twp., Haliburton Co., Sept. 16, 1966, R.F. Cain, TRTC #44650 (part as DAOM #158501); Oxbow Lake, Haliburton Co., Aug. 20, 1941, R.F. Cain, TRTC #18261 (part as DAOM #80609); Petawawa F.E.S., Sept. 1, 1941, DAOM #10533; Rondeau Provincial Park, Aug. 8, 1984, RGT #840808/09; Lake Temagami, Aug. 14, 1931, H.S. Jackson, TRTC #2665; Lake Temagami, Sept. 10, 1936, A.H. Smith, TRTC #11475 (part as DAOM #80599); Toronto, Nov. 11, 1946, H.S. Jackson, TRTC #21561; **Quebec**: Cantley, March 1, 1981, J. Ginns, DAOM #180787; Chelsea, Oct. 9, 1936, J.W. Groves, DAOM #6945; Rawdon, May 23, 1981, R. McNeil, DAOM #185912;. **United States: "New England"**:, n.d., W.G. Farlow, Rel. Farlowianae #345, at TRTC. **New York**: Alcove, Oct. 1893, C.L. Shear, New York Fungi #105 (at DAOM); Buffalo, April 1874, G.W. Clinton s.n. (BUF #43355; cited by Peck, 1886, as *Pleurotus atropellitus*). **England**: Littlehampton, Sussex, April 26, 1959, D.A. Reid, DAOM #66623. **West Germany**: Oberammergrau, Aug. 1891, Allescher & Schnabl, Fungi bavarici s.n. at TRTC.
Mating System: Heterothallic, tetrapolar. Nine monokaryons of RGT #840808/09 (collected on *Pinus strobus*) yielded 4 A1B1, 1 A2B2 and 4 A1B2. Six monokaryons of RGT #840910/03 (from *Acer saccharum*) yielded three each of two compatible mating types, and were interfertile with those of #840808/09. Nine monokaryons of RGT #840915/03 (from *Thuja occidentalis*) yielded one each of A1B1 and A2B2, 4 A1B2, and 3 A2B1.
Cultural Characters: Nematode negative, conidia none,

Figure 27: *Resupinatus striatulus*. A) R.G. Thorn #840808/09, on *Pinus*, X 6. B) RGT #820922/06, on *Acer*, X 2.2

A
B

neither in pure culture (PDA, MEA) nor on WA with nematodes. Vegetative hyphae in sections beneath fruit bodies are smooth, hyaline, clamped, (0.8) 1.5-4.0 µm diam., forming appressoria and penetration pegs 0.1-0.2 µm diam. to pierce cell walls where they do not pass through bordered pits, passing directly through most cells but present in abundance in areas of high microbial activity, including the surface of the wood where they appear associated with free-living algae, rarely producing droplets up to 4 µm diam., from fine, tapering pegs 1.5-4 µm long, 0.2-0.4 µm diam at the tip.

Observations: The distinctive features of this species are its small size, cupulate habit, and glabrous to pruinose cap that is translucent striate or slightly sulcate on the margin. Spore size and all other microscopic characters examined merge with those of *R. applicatus* sensu stricto. The macroscopic differences between the extremes of these two species are striking. *R. applicatus* has flabelliform fruit bodies that are grayish tomentose on the disk, and 5 to 10 times larger than those of *R. striatulus*. In addition, *R. striatulus* occurs on old and well-rotted wood that is without bark, and is usually soft and white-rotted, whereas *R. applicatus* occurs most commonly on the bark of hardwood logs such as *Quercus* and *Acer*, or on hard rinds formed on hardwood logs by fungi such as *Ustulina deusta*.

Resupinatus trichotis (Pers.) Singer (1961: 48) Figs. 29 & 30
- = *Agaricus trichotis* Persoon (1828: 18)
- = *Agaricus racodium* Berkeley & Curtis (1859: 288)
  - = *Pleurotus rhacodium* (Berk. & Curt.) Saccardo (1887: 380)
  - = *Pleurotus applicatus* (Batsch: Fr.) Kummer f. *rhacodium* Pilát (1935: 67)
  - = *Resupinatus rhacodium* (Berk. & Curt.) Singer (1951: 253)
- = *Resupinatus subrhacodium* Singer, in Singer & Digilio (1952: 104)

Pileus cupulate to orbicular, dimidiate, or reniform, up to 1.5 cm broad by 0.8 cm long, sessile, grey (7E-F2) to

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Figure 28 A-G: *Resupinatus striatulus*. A-C) Libert #19-A. A) Diverticulate elements of gill edge; B) basidia; C) basidiospores. D-G) R.G. Thorn #840728/03. D) Basidia; E) basidiospores; F) diverticulate cheilocystidia; G) diverticulate cuticular hyphae.

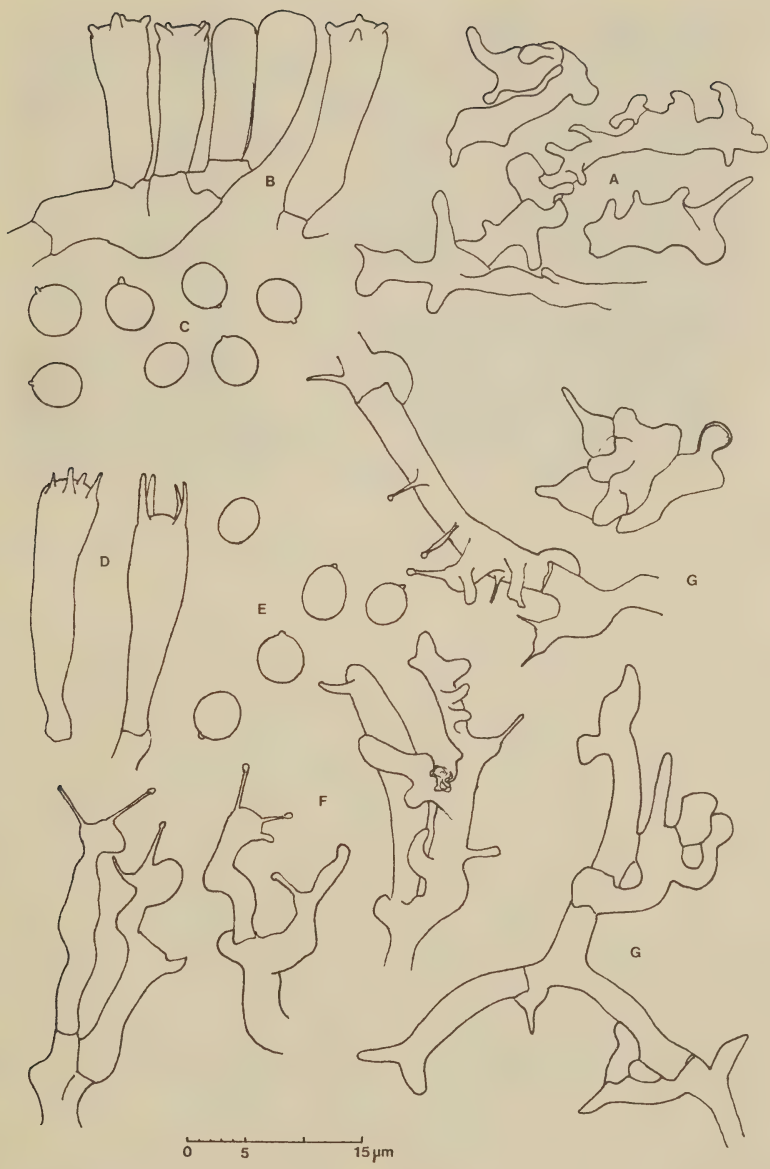
A
B
C
D
E
F
G
G
0
5
15 µm

Figure 29: *Resupinatus trichotis*, R.G. Thorn #850905/05, X 1.5. Note disk of black tomentum on overturned fruit bodies.

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blackish brown or black, with a raised central disk of black, shaggy hairs; margin pruinose when young, to glabrous, not striate. **Gills** radiating from point of attachment or from a point in the centre or off-centre on the underside, narrow, moderately spaced, at first greyishbrown (7D3) to brownish grey (7D2) to nearly black (7-8F2-1), with minutely floccose white margins. **Epicutis** of dark brown hairs up to 700 µm tall X 2-3 um diam, some joined to form fascicles 25-30 µm broad. **Cuticle** black, dark brown in section in KOH, about 25 µm thick. **Gelatinous Zone** 300-400 µm thick, hyaline, of tangled and vertically arranged hyphae 1.5-2.5 µm diam., with clamps. **Trama** pale brown in KOH, slightly gelatinised, more dense, 30-50 µm deep, descending into gills to form gill trama. **Subhymenium** dark brown, dense, 10-70 µm thick. **Hymenium** pallid, 26-32 µm thick. **Basidia** 4-pronged, clavate-cylindric, 24-28 (33) X 5.5-7.0 µm. **Cheilocystidia** clavate to ventricose, 25-30 X 5-6.5 µm; with tortuous, finger-like projections about 1.5-2.0 µm in diam. **Spores** globose, hyaline, inamyloid, smooth, (4.5) 4.8-6.5 X (4.2) 4.5-5.0 (5.5) µm.

Habitat: on rotting hardwoods, recorded from *Fagus*, *Fraxinus* and *Salix*.

Distribution: Reported from Great Britain, Hungary, Italy and Yugoslavia (Babosne, 1976), Holland (Reijnders, 1977),

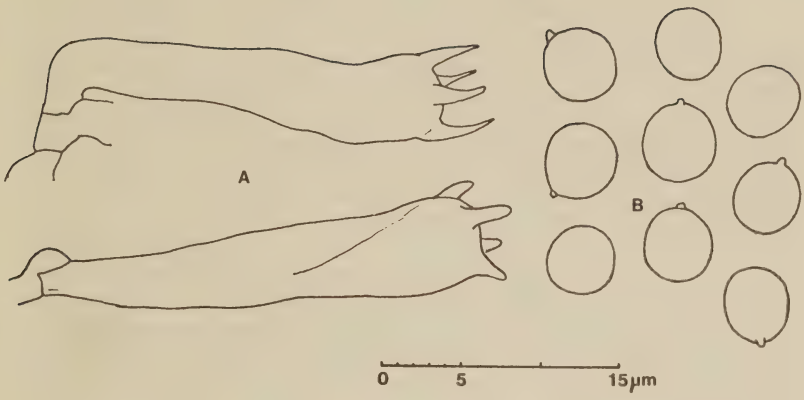

Figure 30 A-B: *Resupinatus trichotis*, R.G. Thorn #850905/05. A) Basidia; B) basidiospores.

Pennsylvania in the United States (Berkeley and Curtis, 1859), Argentina and Brazil (Singer and Digilio, 1952, as *R. subrhacodium*), Japan (Imazeki and Hongo, 1965; Hongo, 1978), and found in New Brunswick and Ontario, Canada.
Specimens Examined: Canada: New Brunswick: Lobster Cove Point, near Chance Harbour, St. John Co., Sept. 5, 1985, R.G. Thorn #850905/05. **Ontario**: New Durham, Brant Co., Sept. 12, 1958, R.F. Cain, TRTC #33929 (part as DAOM #74474).
Mating System: Unknown.
Cultural Characters: Non-nematophagous, without a *Nematoctonus* asexual state (RGT #850905/05).
Observations: *Resupinatus trichotis* could, like *R. striatulus*, be regarded as one of the more striking variants of *R. applicatus*. Pilat (1935) was of this opinion, and treated it merely as a form of *R. applicatus*. The dark pileus with its dense mat of coarse, black tomentum, and its spherical spores distinguish *R. trichotis* from all other species of *Resupinatus* or *Hohenbuehelia*.

STIGMATOLEMMA Kalchbrenner (1882: 104)
Type species (only original species): *S. incanum* Kalchbr.
= *Porotheleum* Fr.: Fr. subgenus *Stigmatolemma* (Kalchbr.) W.B. Cooke (1957: 687)

= *Rhodocyphella* W.B. Cooke (1961: 105)

Type species, originally designated: *Cyphella cupuliformis* Berkeley and Ravenel (= *Stigmatolemma taxi* fide Donk, 1962 b)

The following generic description is modified from that by Singer (1975): Fruit bodies minute (0.2-1.5 mm diam.), discoid, cup, or goblet-shaped, dispersed or crowded, usually seated in a white or greyish felty or slightly gelatinized stroma (subiculum); hymenium concave, smooth. Spores globose to ellipsoid or short-cylindric, suballantoid, sometimes weakly angular, hyaline, smooth, inamyloid; basidia rather short, (2-) 4-spored; cystidia confined to rim of cup, clavate-diverticulate, hyaline; sterile surface covered with hyaline hairs that merge into subiculum, commonly coralloid-diverticulate and encrusted with hyaline to pale brown (KOH) crystalline material; trama generally fuscous but hyphae not pigment-encrusted; subhymenium of dense, subparallel pigmented hyphae; lower trama hyaline or subhyaline and strongly gelatinized; all hyphae with clamps, inamyloid. On dead wood and stems. Presumed not to have a *Nematoctonus* state.

Observations: *Stigmatolemma* can be recognised among the genera of cyphelloid agarics by its gelatinous context, clamp connections, and greyish tomentum of diverticulate, encrusted hyphae. *Calyptella* Quelet is similar, but paler and not gelatinized.

Singer separates *Stigmatolemma* and *Stromatocyphella* in his key (1975, p. 378) on the basis of the presence of coralloid-diverticulate cuticular hyphae in *Stromatocyphella* and their absence in *Stigmatolemma*. Figure 31, plus those by Redhead (1973) of *Stigmatolemma poriaeforme* and Cunningham (1963) of "*Stromatoscypha*" *huia* clearly show that *Stigmatolemma* has diverticulate cuticular hyphae. Romagnesi (1953, cited in Donk, 1962 b) remarked on this character when comparing *Stigmatolemma poriaeforme* with *Resupinatus kavinii*. Figure 33, and those by Reid (1963) depict comparably diverticulate cuticular hyphae in *Stromatocyphella conglobata* and show that this character can not be used to distinguish these two genera.

Maintaining separate genera for *Stigmatolemma* and *Stromatocyphella* may be justified on the macroscopic characters of their fruit bodies, that is, the cylindric to cupulate, more or less separate fruit bodies of *Stigmatolemma* versus the cespitose cups on a common gelatinous mound in *Stromatocyphella*. It may be that more supporting characters will be added as we learn more about the biology of these genera.

In addition to the widespread *Stigmatolemma poriaeforme*, *S. taxi* (Lev.) Donk also occurs in North America (Donk, 1962 b). Burt (1915) described it (under *Cyphella cupulaeformis*) on the bark of *Juniperus* in Georgia and South Carolina, and Coker (1921) reported it on the same host in North Carolina. It is distinguished by its host range, scattered grey fruit bodies, and angular spores (4.75–5.75 X 4.5–5.25 µm vide Donk, 1962 b). *Stigmatolemma taxi* was not collected during this study nor found in the collections of DAOM or TRTC. *Stigmatolemma conspersum* (Pers.: Fr.) Donk is as yet only known from Europe where it occurs on conifers, but may be represented in North America by a specimen originally labelled *Cyphella grisella* (Quel.) Bourd. & Galz. (considered a synonym of *S. conspersum* by Donk, 1962 b). This specimen (DAOM #22841) was subsequently redetermined as *S. poriaeforme* by W.B. Cooke, who had a broad concept of that species, and was not checked during this study.

The species of *Stigmatolemma* have been treated in a variety of genera over the years. Persoon (1801) and Fries (1822) classified these species in *Peziza*. Once the basidia of these species were recognised, some species were treated in the genus *Cyphella* Fries, some in *Solenia*, and others in *Porotheleum*, depending on how crowded or dispersed the fruit bodies were, and how well-developed the subiculum was. *Stigmatolemma* is not congeneric with the types of any of these three genera (Donk, 1962 b).

Stigmatolemma poriaeforme (Pers.: Fr.) W.B. Cooke (1961: 128) (as *poriaeformis*) Figs. 31 & 32 B & C
= *Peziza anomala* Pers. var. *poriaeformis* Persoon (1801: 656)
= *Peziza poriaeformis* (Pers.: Fr.) Fries (1822: 106)
= *Solenia poriaeformis* (Pers.: Fr.) Fuckel (1872: 301)
= *Porotheleum poriaeforme* (Pers.: Fr.) W.B. Cooke (1957: 688)

Fruit Bodies 180–250 µm diam., about 300 µm tall, nearly cylindric or goblet-shaped, crowded on a felty subuculum. **Cuticle** externally clothed whith hyaline, glassy hairs, 1.5–3.0 (4.0) µm diam., some with gelatinised walls, and inflated, others thin-walled, irregularly warted and lobed, with fine secretory pegs; coated with large (5–20 µm diam.), pale brown, blocky crystals, that in fact are masses of rhombic crystals 5–12 X 1–3 µm; subiculum also covered with diverticulate hairs and cystalline material. **Trama** dark

brown (KOH), densely interwoven, (10) 20-30 (50) µm deep including the poorly-defined subhymenium; hyphae (2) 3-5 µm diam., brown-walled. **Gelatinous Zone** below trama proper, subhyaline and continuous to base and forming a hyaline, gelatinous subiculum 20-50 µm thick. All hyphae, including trama and cuticle, with clamp connections. **Hymenium** subhyaline, 15-20 µm deep. **Basidia** 4-pronged, hyaline, broadly clavate or sphaeropedunculate, (12) 15-18 (22) X 6-8 µm. **Cystidia** confined to rim of cup, clavate or fusoid, diverticulate, hyaline, 12-17 X 3.5-5.0 µm. **Spores** subglobose or globose, hyaline, inamyloid, smooth, (3.0) 3.7-5.5 X (3.0) 3.3-4.5 µm.
Habitat: on rotting hardwoods and rarely conifers, often with a soft brown rot. *Populus* was the most frequent host noted, but specimens in TRTC and DAOM included some on *Acer*, *Fagus*, *Quercus*, *Salix*, *Tilia*, and burnt conifer.
Distribution: Widespread in Europe and North America (Donk, 1962 b) and recorded in New Zealand by Cunningham (1963), who states that it is also found in South America and South Africa.
Specimen Examined: Canada: Ontario: Lot 17, Concession 3 Eramosa Twp. Wellington Co., Sept. 8, 1985, R.G. Thorn #850908/01; Lake Temagami, Kokoko Portage, Sept. 7, 1945, R.F. Cain, TRTC #50198 (part as DAOM #158465); north of Uppsala, Thunder Bay District, Sept. 13, 1944, R.F. Cain, TRTC #20075.
Mating System: Unknown.
Cultural Characters: Unknown in culture, but the following observations were made of hyphae in the substrate that were clearly connected with the basidiocarps of TRTC #50198: **Hyphae** hyaline, smooth or coarsely encrusted, with clamps, 1.5-3.0 µm diam.; with scattered fine, tapering, hyaline pegs 1.0-2.5 (3.0) µm tall by 0.3-0.6 µm at base, tapering to 0.10-0.15 µm at tip; these subtending hyaline droplets (0.8) 2-3 (4) µm diam. Where details of the droplet were visible, the tip of the secretory peg could be seen within the base of the droplet, inflated to about 0.2 µm diam. **Conidia** none seen.

Figure 31 A-F: *Stigmatolemma poriaeforme*, all TRTC #50198 (DAOM #158465). A) Vegetative hyphae with microdroplets; B) section of wood cell beneath fruit bodies, showing arrangement of hyphae and microdroplets; C)diverticulate cuticular hyphae; D) hymenial elements from cup margins (?cheilocystidia); E) basidia and a basidiole; F) basidiospores.

A
B
0
100 µm
F
E
C
0
5
15 µm
D

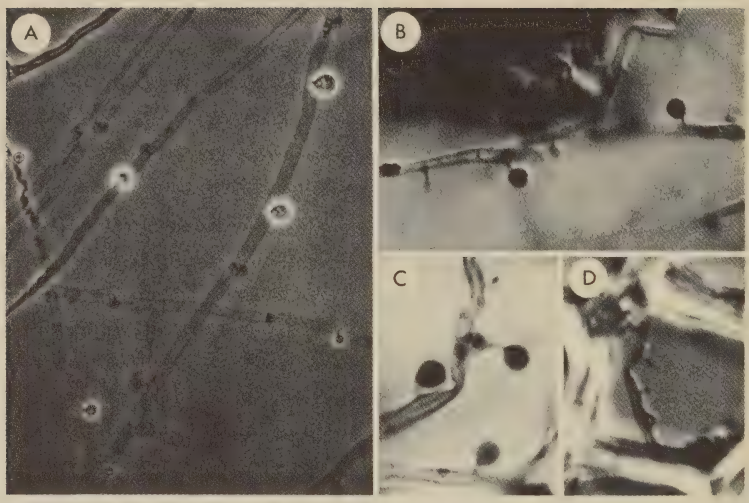

Figure 32. A) Droplets of toxin on hyphae of *Pleurotus ostreatus* (R.G. Thorn #820923/12) in culture on water agar with nematodes, X 550, reproduced, with permission, from McIlvainea 7 (1): 20 (1985); B and C) microdroplets on vegetative hyphae of ***Stigmatolemma poriaeforme*** (TRTC #50198) in substrate beneath fruiting bodies, X 660; D) droplets forming on hyphae beneath fruiting bodies of ***Resupinatus striatulus*** (RGT #840808/09), X 500.

Observations: ***Stigmatolemma poriaeforme*** may be recognised by its greyish, tomentose, cylindric or cup-shaped, minute fruit bodies crowded on a greyish mat, its gelatinous flesh, and globose spores. ***Stigmatolemma conspersum*** has oblong-cylindric spores 6-9 X 3-4 µm (Bourdot and Galzin, 1928), and occurs on conifers, notably ***Abies*** (Donk, 1962 b). ***Stigmatolemma taxi***, known from Europe and the south-eastern United States (where Burt, 1915, and Coker, 1921, recorded it as ***Cyphella cupulaeformis***) occurs on ***Taxus*** and ***Juniperus*** and differs in its angular globose or ovoid spores 4.75-5.75 X 4.5-5.25 µm (Donk, 1962 b).

The microdroplets on the vegetative hyphae of this species are of interest, but their role is unknown. These microdroplets greatly resemble those found in cultures of ***Pleurotus ostreatus*** that immobilise nematodes on contact (Thorn and Barron, 1984; Fig. 32 A). Droplets of similar appearance have been illustrated by Redhead (1973), occurring on the cuticular hyphae of ***S. poriaeforme***, and

have been found on vegetative hyphae of *Resupinatus striatulus* (Fig. 32 D).

STROMATOCYPHELLA W.B. Cooke (1961: 104)

Type species, originally designated: *S. conglobata* (Burt) W.B. Cooke.

The following description is based on those by Reid (1963) and Singer (1975): Fruit bodies consisting of small (0.4-1.5 mm diam.) cups crowded on a common, gelatinized mound, sometimes fusing with adjacent cups; hymenium smooth, concave; trama monomitic, strongly gelatinized, all hyphae with clamp connections, inamyloid. Epicutis a tangle of coralloid-diverticulate, often thick-walled hyphae, secreting what becomes crystalline encrusting material. On wood. Presumed not to have a *Nematoctonus* asexual state.

Observations: This monotypic genus is remarkable and distinctive. All specimens examined were correctly identified by their collectors, which is far from the case with the gilled members of the Resupinateae. Burt (1915) remarked that *Cyphella conglobata* was so unusual that it might some day form the type of a new genus. The cyphelloid habit is considered a reduction from gilled forms in the genus *Resupinatus* sensu stricto. The diverticulate, encrusted cuticular hyphae of these two genera are very similar.

Reid (1963) has shown that the other two species originally included by Cooke (1961) in *Stromatocyphella* are not congeneric. According to Reid, *S. lataensis* W.B. Cooke is a synonym of *Flagelloscypha erucaeformis* (Batsch: Fr.) Singer, and *S. aceris* W.B. Cooke is a member of *Cyphellopsis* Donk, possibly *Cyphellopsis anomala* (Pers.: Fr.) Donk or *C. confusa* (Bres.) Reid.

Stromatocyphella conglobata (Burt) W.B. Cooke (1961: 104)

Fig. 33

= *Cyphella conglobata* Burt (1915: 375)

The following description is taken from TRTC #5452 (part as DAOM #8882):

Fruit Bodies reviving well in water, consisting of approximately hemispherical cups 0.4-1.2 mm diam., densely gregarious on a common stalk, erupting in groups of 5-25 from lenticels in the alder bark. When wet the margins appear glabrous or finely pruinose, a reddish caramel colour (6-7C4); the hymenium similar or paler honey-brown (5B4), smooth and satiny, concave; bases of the cups darker (6-7E5), and more coarsely pruinose to tomentose with brown

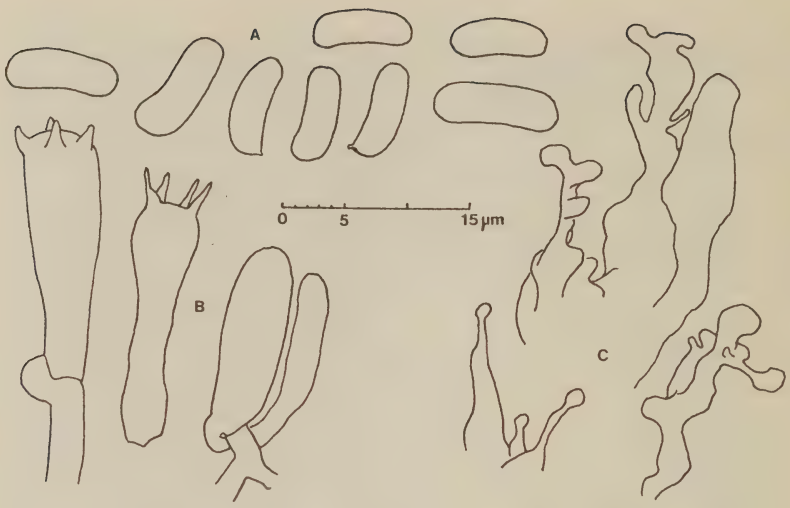

Figure 33 A–C: *Stromatocyphella conglobata*, TRTC #5452. A) Basidiospores of *S. conglobata*; B) two basidia and two basidioles; C) cuticular hyphae.

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hairs. On drying the margins roll inward, and whole fruit body becomes silvery (B1), the exterior appearing pruinose to tomentose. **Stroma** subtending cups, subhyaline, more or less conical, strongly gelatinised, hyphae tangled, 1.5–3.0 µm diam. **Cuticle** of cups a pale to dark brown (KOH) zone 25–35 µm deep, of basically parallel, repent hyphae 2–5 µm diam. **Epicutis** a tangled zone of more or less vertical, branching, encrusted brown diverticulate hairs, mostly 2–3 µm diam., with branchlets 0.5–1.0 µm diam.; both hairs and cuticle obscured by dense, brown granular-crystalline encrustations that gradually dissolve in 3% KOH. **Trama** consisting of three zones: an outer, strongly gelatinised zone with hyaline hyphae (1.5) 2.0–4.0 (5) µm diam. tangled, but basically perpendicular to hymenium, 25 µm deep in cup margins to 100 µm deep at their bases, and continuous with stroma; a hyaline zone 25–40 µm deep of hyaline, slightly gelatinised hyphae 1.5–3.0 µm diam., running parallel to hymenium; a pale brown zone continuous with the last, 20–35 µm deep, of radially-arranged, parallel, smooth hyphae 1.5–4 µm diam., not or only slightly gelatinised. **Subhymenium** deep brown in KOH, 25–30 (50) µm deep, slightly to strongly gelatinised, hyphal walls not visible in some areas, those visible rising in a tangle to hymenium, 2–5 µm diam.

Hymenium hyaline, 20-27 µm deep. **Basidia** 4-spored, hyaline, clavate, 23-28 X 6.0-7.5 µm. **Cystidia** not seen. **Spores** hyaline, inamlyoid, smooth, cylindric, dented on one side, or slightly curved, only rarely with a fine, oblique apiculus, (6.0) 8.0-10.0 X 3.0-3.8 µm.
Habitat: On dead hardwood branches, usually of *Alnus*, but also noted on *Betula* and *Juglans* (Cooke, 1961).
Distribution: Known only from North America, where it has been recorded in Michigan (Reid, 1963), New Hampshire, New York, and Pennsylvania in the United States and British Columbia, New Brunswick, Ontario and Quebec in Canada (Cooke, 1961).
Specimens Examined: Canada: Ontario: Bell's Lake, north of Parry Sound, Sept. 20-22, 1934, H.S. Jackson, TRTC #5452 (part as DAOM #8882). A total of 6 other collections were seen at TRTC and DAOM, all confirmed and cited by W.B. Cooke.
Mating System and Cultural Characters: Unknown. Neither conidia nor microdroplets were seen on vegetative hyphae in sections beneath fruit bodies.
Observations: *Stromatocyphella conglobata* is a distinctive fungus, but is small, inconspicuously coloured, and possibly easily missed. A search of alder thickets during this study failed to reveal this species. *Stromatocyphella conglobata* can be recognised by its pendant clusters of cups growing from a gelatinous trunk, protruding from the lenticels or cracks in the bark of dead branches, usually *Alnus*. The cups are reddish brown when fresh and silvery when dry.

GENERAL CONCLUSIONS

Eight species of *Nematoctonus*, five of them new, occur in Ontario. An additional new, extralimital species of *Nematoctonus* brings the total number of species in the genus to 16. Seven of these have teleomorphs in *Hohenbuehelia* (Table 3). Nine species have no known teleomorph, but one may be found in the future for some, such as *N. concurrens* and *N. haptocladus*. It seems unlikely that some other species, such as *N. leiosporus*, *N. tylosporus* and *N. leptosporus* will be found to have teleomorphs. These are endoparasitic species that have evolved as nematophagous fungi, even to the extent of host specialisation.

Twelve species of *Hohenbuehelia* occur, or are likely to occur, in Ontario. All have *Nematoctonus* anamorphs (Table 3). The anamorph of *H. approximans*, *H. cyphelliformis*, *H. atrocaerulea* var. *grisea*, and *H. nigra* is *N. robustus*. The anamorph of *H. petalodes* and *H. tremula* is *N. geogenius*.

Table 3. Anamorphs and Teleomorphs of *Nematoctonus* and the Resupinateae

Teleomorph	Anamorph
Ontario Species	
Hohenbuehelia angustata	*Nematoctonus angustatus*
H. approximans	*N. robustus*
H. atrocaerulea var. *grisea*	*N. robustus*
H. cyphelliformis	*N. robustus*
H. mastrucata	*N. hamatus*
H. petalodes	*N. geogenius*
H. pinacearum	*N. brevisporus*
H. tremula	*N. geogenius*
H. unguicularis	*N. brevisporus*
H. sp. (Singer, ined.)*	*N. pachysporus*
None Known	*N. leiosporus*
None Known	*N. leptosporus*
None Known	*N. subreniformis*
Resupinatus applicatus	None
R. striatulus	None
R. trichotis	None
Stigmatolemma poriaeforme	None Known**
Stromatocyphella conglobata	None Known**
Extralimital Species	
Asterotus dealbatus	None known**
H. longipes	*Nematoctonus* sp.
H. nigra	*N. robustus*
H. portegna	*N. campylosporus*
Hohenbuehelia sp. (stirps Petaloides s. str.)	*Nematoctonus cylindrosporus*
None Known	*N. concurrens*
None Known	*N. haptocladus*
None Known	*N. lignicola* nom. invalid.
None Known	*N. tripolitanius*
None Known	*N. tylosporus*
Resupinatus alboniger	None

*Teleomorph not known from Ontario

** No cultures available; no signs of *Nematoctonus* anamorph in substrate of fruit bodies

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Certain related species of *Hohenbuehelia* have anamorphs referrable to the same form-species. This is due in part to the greater number of taxonomic characters available for the classification of the teleomorphs. Connections are made for the first time between twelve species of *Hohenbuehelia* and their anamorphs. The anamorph of an additional species of *Hohenbuehelia*, *H. longipes*, was illustrated by Kuehner et al. (1962), but has not been isolated since, or identified.

Hohenbuehelia differs from *Resupinatus* in several major characters. The most important difference is one of biology: species of *Hohenbuehelia* have *Nematoctonus* anamorphs that are nematophagous, whereas species of *Resupinatus* do not.

Several morphological characters are correlated with this biological distinction. Fruit bodies of *Hohenbuehelia* have hymenial metuloids (sometimes inconspicuous) and gloeosphex cystidia, the apices of which resemble the adhesive knobs in *Nematoctonus*. The cuticle of most species of *Hohenbuehelia* is a cutis of repent, tangled, tubular hyphae. These hyphae may be smooth or pigment-encrusted, but are without conspicuous lobes or branchlets. The cuticle of *Resupinatus* species is a rameales structure composed of branched, knobbed, or spiny hyphae, which often secrete so much crystalline or amorphous encrusting material that these details are obscured. The cheilocystidia of *Resupinatus* are likewise diverticulate and encrusted, and never have the hour-glass secretory cells characteristic of *Hohenbuehelia*. Species of *Resupinatus* lack hymenial metuloids. Nonetheless, the two genera are closely related, and particularly so in *R. alboniger*. This species has elliptical spores like most species of *Hohenbuehelia* (and unlike most other *Resupinatus*), and occasional thick-walled cystidia. These cystidia, however, do not stain in cresyl blue, and are not true metuloids. In addition, *R. alboniger* does not have a *Nematoctonus* anamorph, and is thus not a *Hohenbuehelia*.

Good key characters are available to identify all Ontario species of the Resupinateae (many of which occur worldwide), once discordant elements are weeded out of the species concepts. The classifications of anamorphs and teleomorphs are mutually supporting at the species level, as well as the generic level. Certain related species of *Hohenbuehelia* share anamorphs of the same form-species, yet the distinct anamorph of *H. auriscalpium* (*N. cylindrosporus*) shows that it is distinct from *H. petalodes* (anamorph *N. geogenius*), with which it is often synonymised.

Species of *Resupinatus* may not have *Nematoctonus* anamorphs that consume nematodes, but their biology is completely unresolved. Little is known about *Asterotus*, *Stigmatolemma* and *Stromatocyphella*, except that the morphological evidence indicates that these genera are more related to *Resupinatus* than they are to *Hohenbuehelia*. The nematophagous habit indicates the relationship of the Resupinateae to the genus *Pleurotus*. This is supported by the similar cystidia in *Resupinatus* and *Pleurotus*, the microdroplets of *Resupinatus* and *Stigmatolemma* that are visually identical to those of *Pleurotus*, and the similar spore morphology of *Pleurotus* and the Resupinateae. For these reasons it is suggested that the tribe Resupinateae be classified in the family Polyporaceae (= Pleurotaceae), as has been done by Kuehner (1980), rather than in the

Tricholomataceae (Singer, 1975, and others). Julich (1981) classified *Hohenbuehelia* and *Geopetalum* (= *Faerberia*) in the Geopetalaceae of the Polyporales, and *Resupinatus* in the Resupinataceae of the Tricholomatales. We believe that *Hohenbuehelia* and *Resupinatus* are members of the same tribe, and not members of different orders. In addition, *Faerberia* appears not to be directly related to the Resupinateae.

Thorn and Barron (1984) suggested that the consumption of nematodes provides species of *Hohenbuehelia* with valuable supplementary nitrogen. Species of *Hohenbuehelia* occur most commonly on well-rotted wood, or on woody debris in rich sites where there is intense microbial competition for available nitrogen. Since nitrogen limitation probably affects most lignicolous fungi (Thorn and Barron, 1984), it is interesting to wonder how many other such fungi capture and consume nematodes. Of 20 genera of lignicolous agarics and polypores tested (Thorn and Barron, 1984; and unpublished data), only *Hohenbuehelia* and *Pleurotus* were capable of preying on nematodes.

Although what may be the most interesting questions about the biology of the Resupinateae remain to be answered, these questions are more apparent, and the answers more easily attained, with a clearer understanding of the taxonomy of this group.

ACKNOWLEDGEMENTS

We thank Dr. J.A. Parmelee (DAOM) and Dr. J. Krug (TRTC) for loan of specimens and facilities provided while the senior author visited these herbaria; Dr. J.H. Haines (NYS), Dr. P.K. Holmgren (NY), Dr. G.G. Lorenzoni (PAD), Dr. D.H. Pfister (FH), and Dr. D.A. Reid (K), for the loan of type or authentic specimens; the many individuals and institutions that provided cultures and specimens used in this study; Dr. O.K. Miller, Jr. (VPI) and Dr. R. Singer (F) for cultures, specimens and valuable correspondence regarding *Hohenbuehelia*; and Mr. G. Whitney, superintendent of Algonquin Provincial Park, Ontario, for permission to collect fungi and soil samples there. In addition, Dr. S.A. Redhead (DAOM) provided advice on agaric taxonomy and nomenclature and, with M. Leleu, helped locate necessary but obscure taxonomic references. Dr. J.H. Ginns (DAOM) and Dr. K.A. Harrison (ACAD) reviewed this paper. This study was funded in part by an operating grant to Dr. Barron from the Natural Sciences and Engineering Research Council of Canada. Technical assistance was provided by S. Lackie and E. Szijarto.

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APPENDIX 1: MEDIA AND REAGENTS

Acetic Alcohol: Three parts 95% ethanol: one part glacial acetic acid. **ANT B Agar**: 4 mL of a 0.3% sterile aqueous solution of chlorotetracyclin ("aureomycin" - gives 60 ppm), 2 mL of a 0.3% penicillin-G solution (30 ppm), 2 mL of 0.3% streptomycin solution (30 ppm), and 0.5 mL of a 0.1% solution of technical benomyl in acetone (gives 2.5 ppm), all added aseptically to 200 mL PDA just before pouring plates. **Brilliant Cresyl Blue**: a 0.05 % aqueous solution (w/v) of cresyl blue (B.D.H. Chemicals lot 2982670) **Melzer's Reagent**: 1.5 g KI dissolved in 20 mL water, then 0.5 g iodine and 22 g chloral hydrate added. **Nigon's Agar**: 0.75 g magnesium sulphate, 0.75 g dipotassium hydrogen phosphate, 2.75 g NaCl, 3.0 g potassium nitrate, 2.5 g peptone, 1.0 g lecithin, 15 g agar, all added to 1 L distilled water. **PDA** (potato dextrose agar): 200 g potatoes sliced and cooked in 500 mL distilled water for 1 h; the cooking water strained through cheesecloth and brought to 1 L with distilled water; plus 12 g dextrose and 20 g agar; autoclaved in 200 mL medicine bottles. **PD + AB Agar**: 4 mL of a 0.3 % sterile aqueous solution of chlorotetracycline ("aureomycin" - gives 60 ppm) and 0.5 mL of a 0.1% solution of technical benomyl in acetone (gives 2.5 ppm) added aseptically to 200 mL PDA just before pouring plates. **PVLG**: 50 mL of a 20% w/v aqueous solution of Sigma polyvinyl alcohol type II, with a viscosity of 20-30 centipoises at 20 degrees C, mixed with 50 mL 85% lactic acid and 5 mL glycerin (modified from Koske and Tessier, 1983). **Saline**: 0.85 % w/v solution of NaCl in distilled water. **Trypan Blue**: 0.05% w/v solution of trypan blue (Allied Chemical lot 12652) in a 14:1:1 mix of 85% lactic acid: glycerin: water. **WA** (water agar): 20 g Difco Bacto agar per litre distilled water.

MYCOTAXON

Vol. XXV, No. 2, pp. 455-460 April-June 1986

New Species Dekkera custersiana and D. lambica, Teleomorphs of Brettanomyces

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Summary

Dekkera custersiana sp. nov. and D. lambica sp. nov. are described to accommodate the perfect states (teleomorphs) of Brettanomyces custersianus van der Walt and B. lambicus Kufferath et van Laer, respectively. Ascospore formation is best observed in cultures at room temperature after one week on the vitamin-enriched Endothia complete medium (ATCC medium 686) with a pH of 4.5.

The teleomorphs or ascogenous states of Brettanomyces Kufferath et van Laer are now classified in the genus Dekkera van der Walt (3,4,5,10,11). In our authentication of the yeast strains maintained in the American Type Culture Collection (ATCC), the type cultures of Brettanomyces custersianus van der Walt ATCC 34446 and B. lambicus Kufferath et van Laer ATCC 10563 were found for the first time to produce hat-shaped ascospores on ATCC medium 686 (2), referred to as Endothia medium (6), supplemented with a vitamin solution (12). Therefore we describe the two yeasts as new species of Dekkera van der Walt (8).

Dekkera custersiana Lee et Jong, sp. nov.

Stat. Anamorphosis: Brettanomyces custersianus van der Walt, 1961.

In extracto malti post 5, 25°C, cellulae ellipsoidae, saepe ogivales, cylindricae elongataeque, 1.5-4 X 3-17μm, singulae, binae aut in catenatae. Cellulae longae pseudomycelii formatur. Sedimentum et annulus imperfectus formatur. Cultura acclivis, superficie limitata, sordida alba et nitida, verrucosa aut crispulata. Margine globro, structuris aut lobiformo. Asci e cellulis dipoidis transformatis oriuntur. Ascosporae pilleiformae ad 4 in quoque asco formantur. Ascosporae maturae ex ascis celeriter liberantur et inter se aggutinantur. Fermentatio, crescentia in variis substantiis carbonaceis et alliae naturae monstrantur in Tabula 1.

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Typus: ATCC 34446 in collectione American Type Culture Collection, Rockville, Maryland, USA.

Growth in malt extract: After 5 days at 25°C the cells are ellipsoidal, frequently ogival, cylindrical to elongate, 1.5-3 X 3-17 µm, reproducing by budding and occurring singly, in pairs or short chains. Pseudomycelium is abundantly formed. A floccose sediment is produced. Islets or a thin pellicle are usually formed. After 10 days at room temperature a thin pellicle is present. Occasionally an incomplete ring is formed. There is a slight production of a characterisitic aroma.

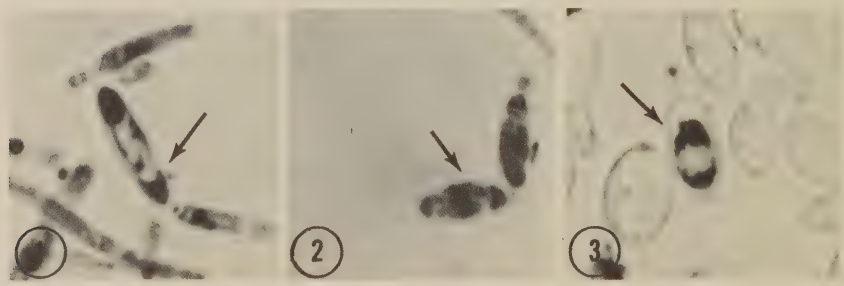
Growth on malt agar: After 6 weeks at room temperature the streak culture is raised, cream-colored to light brown, shiny to somewhat dull, smooth to verrucose. The margin is undulating to lobiform.

Growth on malt agar with 2% calcium carbonate: After 6 weeks at room temperature the streak culture is raised, cream-colored to light brown, shiny to dull, verrucose or rugose. The margin is undulating to lobiform. Acid production is slight.

Dalmau plate culture on corn meal agar: Pseudomycelium is abundantly produced. It consists of filamentous cells with few or no blastospores. Under anerobic conditions, the filamentous cells bear blastospores abundantly.

Physiological characteristics: Fermentation and growth on various carbon compounds, growth on nitrogen sources and some additional properties are summarized in Table 1.

Formation of ascospores: Vegetative cells are transformed directly into unconjugated evanescent asci, producing one to four ascospores. The ascospores are hat-shaped and can be stained with the modified Schaeffer-Fuller malachite green or Ziehl Neelsen's carbol fuchsin (Figs 1 & 2). Mature ascospores tend to agglutinate when liberated. Ascospore formation is observed in cultures at room temperature after one week on Endothia complete medium supplemented with vitamins.



Figs. 1-3. Asci and ascospores of Dekkera custersiana and D. lambica, stained with modified Schaeffer-Fuller malachite green. ca. X 2,000. 1. ATCC 34446 (Type). 2. ATCC 24195. 3. ATCC 10563 (Type).

Brettanomyces custersianus was first described from thirty strains recovered from contaminated equipment in sorghum beer breweries (7). Ascospore formation was not observed in any of the individual strains or in any matings of these strains. One of the strains, CBS 4805 (=ATCC 34446), was designated later as the type culture by van der Walt (9). In the present study, ATCC 34446 and ATCC 24195 have been found to produce ascospores on vitamin-enriched media with a pH of 4-5. Therefore, the new species Dekkera custersiana Lee et Jong is the perfect state (teleomorph) of B. custersianus and ATCC 34446 is designated as the type.

The new species differs from all the presently accepted species of Dekkera and Brettanomyces by its very limited physiological activity (10,11). Morphologically it is allied to B. anomalus Custers because of its marked filamentous nature. It has a coenzyme Q-9 system (13) and 38.9-39.3 mol % of guanine plus cytosine (G + C) of nuclear DNA (1).

Dekkera lambica Lee et Jong, sp. nov.

Stat. Anamorphosis: Brettanomyces lambicus Kufferath et van Laer, 1921.

In extracto malt post dis 5, 25°C, cellulae rotundae, ovoidae, saepe ogivales, cylindricae elongataeque, 2-7 X 4-28μm, singulare, binae aut in catenatae. Cellulae longae pseudomycelii formantur. Sedimentum et annulus formatur. Odor culturae insignitis. Asci e cellulis dipoidis transformatis oriuntur. Ascosporae maturae ex ascis celeriter liberantur et inter se agglutinantur. Fermentatio, cresentia in variis substantiis carbonaceis et alliae naturae monstrantur in Tabula 1.

Typus: ATCC 10563 in collectione American Type Culture Collection, Rockville, Maryland, USA.

Growth in malt extract: After 5 days at 25°C the cells are spheroidal, usually ellipsoidal, frequently ogival, cylindrical to elongate, 2-7 X 4-28μm, reproducing by budding and occurring singly, in pairs, short chains or small clusters. Pseudomycelium is usually present. A sediment is formed. After 10 days at room temperature a flocculent to coherent sediment is present. A slight ring may also be present. A characteristic aroma is usually produced.

Growth on malt agar: After 6 weeks at room temperature the streak culture is cream-colored, shiny, smooth to granular and raised. The margin is entire to undulating.

Growth on malt agar with 2% calcium carbonate: After 6 weeks at room temperature the streak culture is cream-colored, shiny, smooth. The margin is undulating. Acid is produced.

Dalmau plate culture on corn meal agar: Pseudomycelium is abundantly formed both aerobically and anaerobically. It consists of filamentous cells with or without blastospores. The blastospores may be arranged in chain or in somewhat branched verticils.

Physiological characteristics: Fermentation and growth on various carbon compounds, growth on nitrogen sources and some additional properties are summarized in Table 1.

Table 1. Physiological Test Results

	D. custersiana		*D. lambica*
	ATCC 24195	ATCC 34446	ATCC 10563
Growth in vitamin-free medium	-	-	-
Growth at 37°C	+	+	+
Splitting of arbutin	-	-	-
Urea hydrolysis	-	-	-
Diazomium blue B reaction	-	-	-
Acetic acid production	+	+	+
Starch formation	-	-	-
Fermentation of:			
Glucose	D	D	+
Galactose	-	-	-
Maltose	-	-	+
Sucrose	-	-	+
Lactose	-	-	-
Raffinose	-	-	-
Melibiose	-	-	-
Inulin	-	-	-
Cellobiose	-	-	-
Melezitose	-	-	+
Starch	-	-	-
Trehalose	D	D	+
α-Methyl-D-glucoside	-	-	+
Assimilation of:			
Glucose	+	+	+
Galactose	-	-	D
L-Sorbose	-	-	-
Maltose	-	-	+
Sucrose	-	-	+
Cellobiose	-	-	-
Trehalose	D	D	+
Lactose	-	-	-
Melibiose	-	-	-
Raffinose	-	-	-
Melezitose	-	-	+
Inulin	-	-	-
Soluble starch	-	-	-
D-Xylose	-	-	-
L-Arabinose	-	-	-
D-Arabinose	-	-	-
D-Ribose	-	-	-
L-Rhamnose	-	-	-
D-Glucosamine	-	-	-
Ethanol	+	+	D
Methanol	-	-	-
Erythritol	-	-	-

Table 1 (continued)

	D. custersiana		D. lambica
	ATCC 24195	ATCC 34446	ATCC 10563
Glycerol	D	D	D
Adonitol	-	-	-
Dulcitol	-	-	-
D-Mannitol	-	-	-
D-Sorbitol	-	-	-
α-Methyl-D-glucoside	-	-	+
Salicin	-	-	-
Inositol	-	-	-
Lactic acid	+	+	-
Citric acid	-	-	-
Succinic acid	+	+	-
Valine	-	-	-
Glycine	-	-	-
Proline	-	-	-
Arginine	-	-	-
KNO_3	-	-	-
NO_2	-	-	-
Ethylamine	-	-	-

Code in Table: (+) positive; (-) negative; (D) delayed for longer than 7 days

Formation of ascospores: Vegetative cells are transformed directly into asci, producing one to four ascospores. The spores are hat-shaped and can be stained with the modified Schaeffer-Fuller malachite green or Ziehl Neelsen's carbol fuchsin (Fig. 3). Mature ascospores tend to agglutinate when liberated. The occurrence of ascospore formation in the cultures of ATCC 10563 depends greatly on media which have been adequately enriched with vitamins. Sporulation is best observed in cultures at room temperature after one week on the Endothia complete medium (ATCC medium 686) supplemented with vitamins.

Brettanomyces lambicus Kufferath et van Laer has been recovered from Belgian lambic beer and South African grape must (11). Since the designated type culture ATCC 10563 which was originally isolated by M. Th. J. Custers in 1940 from lambic beer is the type of B. lambicus, the new species Dekkera lambica Lee et Jong is the perfect state (teleomorph) of B. lambicus. As in all the presently accepted species of Dekkera and Brettanomyces, D. lambica has a coenzyme Q-9 system (13). The G & C content of the nuclear DNA of this species is 38.7 mol % (1).

Physiologically D. lambica occupies an intermediate position between D. bruxellensis and D. intermedia. It differs from D. bruxellensis in that it assimilates galactose albeit slowly. On the other hand, D. lambica is distinguished from D. intermedia by the absence of cellobiose and salicin utilization and by not splitting arbutin (10,11).

We acknowledge with appreciation the critical review of the manuscript by Mary Jane Gantt. The work was supported in part by the National Science Foundation Grants DEB 7921031 and BSR 8413523 and by the National Institutes of Health Contract N01-OD-5-2117.

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MYCOTAXON

Vol. XXV, No. 2, pp. 461-466 April-June 1986

STUDIES IN THE GENUS *PHOMA*. V. CONCERNING *PHOMA POMORUM*.

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ABSTRACT

Phoma pomorum Thümen [*Phoma prunicola* (Opiz) Wollenw. et Hochapf.] is described and illustrated. Its cultural characteristics and the structure of its pycnidial wall are documented.

INTRODUCTION

During a study of *Phoma americana* Morgan-Jones et White, which formed the subject of the first paper in this series (Morgan-Jones and White, 1983), we had occasion to compare it with *Phoma pomorum* Thümen, the species which it most closely resembles. Both belong to a small group of species which readily produce phaeodictyochlamydospores *in vitro*. All told, some seven species of *Phoma* bear chlamydospores but, as previously pointed out (White and Morgan-Jones, 1983), they are by no means easy to distinguish from one another with the singular exception of *Phoma epicoccina* Punithalingam, Tulloch et Leach, to whose chlamydospore state the binomial *Epicoccum purpurascens* Ehrenb. has long been applied. To facilitate confident and correct identification of *Phoma pomorum*, a comprehensive account of its characteristics is offered here. An attempt has been made to add further diagnostic criteria to those already in part documented (Boerema *et al.*, 1965; Morgan-Jones, 1967). These include colony growth rates and appearance, together with particulars of pycnidial wall organization.

Phoma pomorum is ubiquitous on many different substrates and is cosmopolitan in distribution. It appears to be more common in regions having temperate climates and is frequently present as a secondary invader on leaf spots of apple, pear and plum (Crabhill, 1913; Wollenweber and Hochapfel, 1936; Boerema and Dorenbosch, 1965). It is also known to occur with regularity on seed coats of a wide variety of plants (Leduc, 1958).

This fungus has had a rather complicated nomenclatural history, numerous names having been applied to it (Boerema *et al.*, 1977). Over the years, the binomial *Phoma prunicola* (Opiz) Wollenw. et Hochapfl. has predominated (see Morgan-Jones, 1967). However, although application of the

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Alabama Agricultural Experiment Station Journal Series No. 6-85904.

specific epithet *prunicola* predates that of *pomorum* by more than twenty years, it cannot be adopted since the binomial is a later homonym of *Phoma prunicola* Schweinitz, a different fungus [a species of *Asteromella* Pass. et Thüm.]. It should also be noted that the basionym *Depazea prunicola* Opiz, the type material of which is extant, is a *nomen nudum*, having been published without a description. Another older binomial than *Phoma pomorum* also exists for this fungus, namely *Phyllosticta pyrina* Sacc. Transfer of this to *Phoma* Sacc., would, however, create yet another illegitimate homonym [of *Phoma pyrina* (Fr.) Cooke, a synonym of *Myxofusicoccum mali* (Bres.) Weindlmayr].

TAXONOMIC PART

Phoma pomorum Thümen, Fungi Pomicoli: 105, 1879 (Plate 1, figure 1)

= *Depazea prunicola* Opiz, Malá Encyclop. Nauk. Náklad. česk. Mus. 10: 120, 1852.

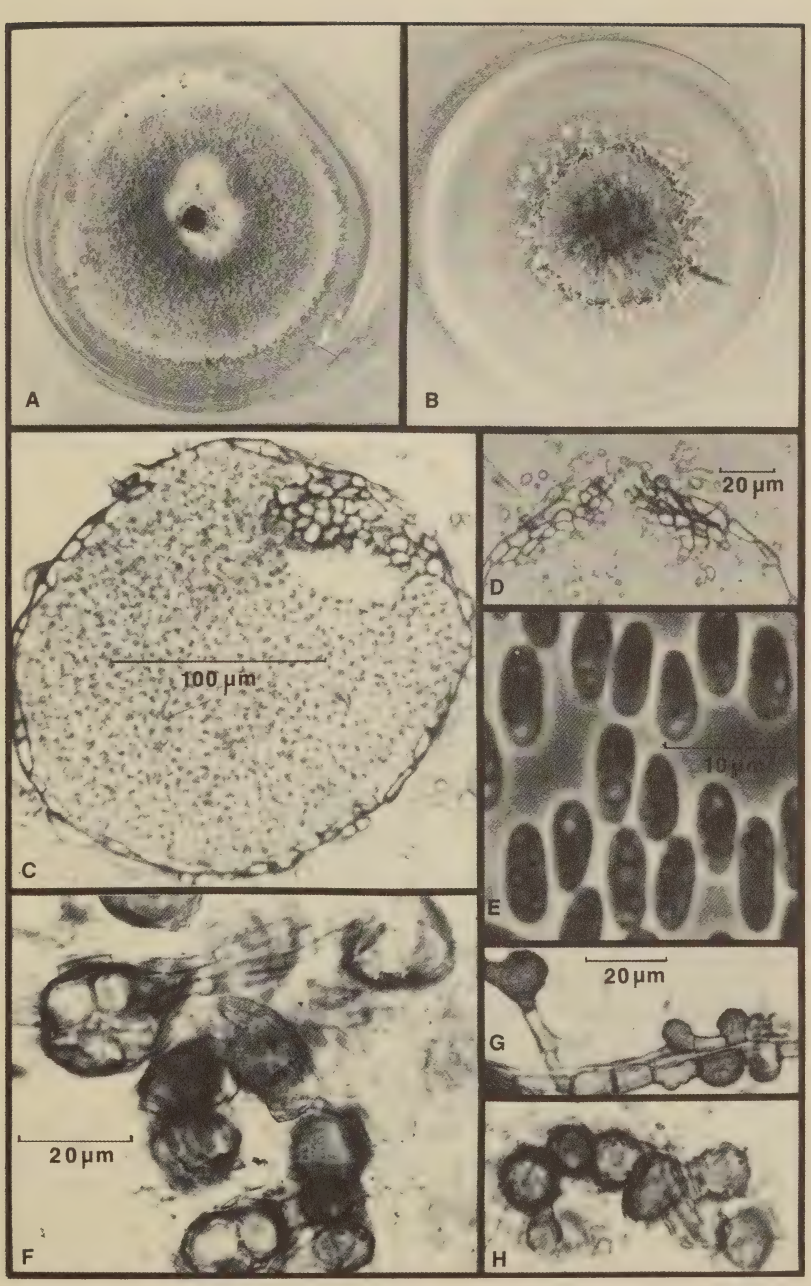
≡ *Phoma prunicola* (Opiz) Wollenw. et Hochapf., Z. Parasitkde 8: 595, 1936 [non *Phoma prunicola* Schweinitz, Trans. Am. phil. Soc. II, 4: 249, 1832].

= *Phyllosticta pyrina* Saccardo, Michelia 1: 134, 1878.

[For full synonymy see Boerema *et al.*, 1965, 1971, 1973, 1977]

Colonies on potato dextrose agar [Difco] (Plate 1, A) lanose to somewhat felty, smoky gray to olivaceous green, remaining whitish at the center and with a pale, more or less even margin, aerial mycelium abundant, attaining a diameter of 65mm at 20C after 6 days, 75mm at 25C and 25mm at 30C; reverse brownish to blackish underneath olivaceous green portions of colony, cream-colored eleswhere. Colonies on malt extract agar (Plate 1, B) densely caespitose and dark olivaceous green at the center, sparse elsewhere, salmony to whitish, with radiating, appressed, fasciculate strands of hyphae and a loose concentric ring of ascending, white hyphal tufts peripherally, attaining a diameter of 55mm at 20C after 6 days, 75mm at 25C and 25mm at 30C; reverse olivaceous green in center, colorless eleswhere. Pycnidia produced abundantly on both PDA and MEA after ten days, superficial or partly immersed in the agar. Colonies on cellulose agar with very little aerial mycelium but producing abundant pycnidia superficially after two weeks. Mycelium composed of septate, branched, subhyaline to pale brown, smooth or very slightly roughened, 2-5µm wide hyphae which are sometimes arranged in funiculose strands, especially on MEA. Pycnidia solitary or frequently confluent, subglobose, without a pronounced neck, pale to dark brown, darker in the immediate vicinity of the ostiole, pseudoparenchymatous, uni or bi-ostiolate, glabrous, 75-175µm in diameter where solitary (Plate 1, C & D; Figure 1, A); where confluent the pycnidial group can reach up to 400µm in diameter and contain as many as ten individual units. Pycnidial wall composed of more or less isodiametric or elongated cells, in two

PLATE 1. *Phoma pomorum*. A, two-week-old colony on potato dextrose agar; B, two-week-old colony on malt extract agar; C, vertical section of pycnidium; D, vertical section through pycnidial ostiole; E, conidia; F-H, chlamydospores.


A
B
100 µm
C
20 µm
D
10 µm
E
20 µm
F
20 µm
G
H

discernible layers, up to 22µm wide, thicker around ostiole (Plate 1, D). Wall four to five cells deep except in the vicinity of the ostiole where there may be as many as seven. Cells around the ostiole mostly isodiametric and angular, 2-4µm wide, the remainder of the superficial wall cells somewhat cylindrical, 5-8 X 2-4µm. Cells of outer wall layer appreciably thicker-walled than those lining the pycnidial venter (Figure 1, C). Conidiogenous cells phialidic, hyaline, simple, smooth-walled, flask-shaped, 3-4µm in diameter, lining the entire inner wall surface up to the ostiolar region. Conidia hyaline, simple, oblong with obtuse ends or narrowly ellipsoid, continuous, guttulate (frequently having one large guttule and several slightly smaller ones), 5-8 X 2-3µm. Exuded conidial mass whitish to cream in color. Chlamydospores highly variable, produced abundantly on PDA and MEA, terminal and intercalary, single or in chains, subglobose, ellipsoid or clavate, simple, phragmosporous or dictyosporous, where simple (unicellular) mostly in chains of up to twenty elements, occasionally produced as unilateral inflations of intercalary hyphal cells (Plate 1, G), thick-walled, roughened or, more rarely, smooth, sometimes having a slightly scurfy appearance, pale brown to brown, where dictyosporous (Plate 1, F) occasionally appearing to have discrete individual cell wall layers within an outer enveloping one, 10-30µm in diameter.

Ubiquitous and cosmopolitan.

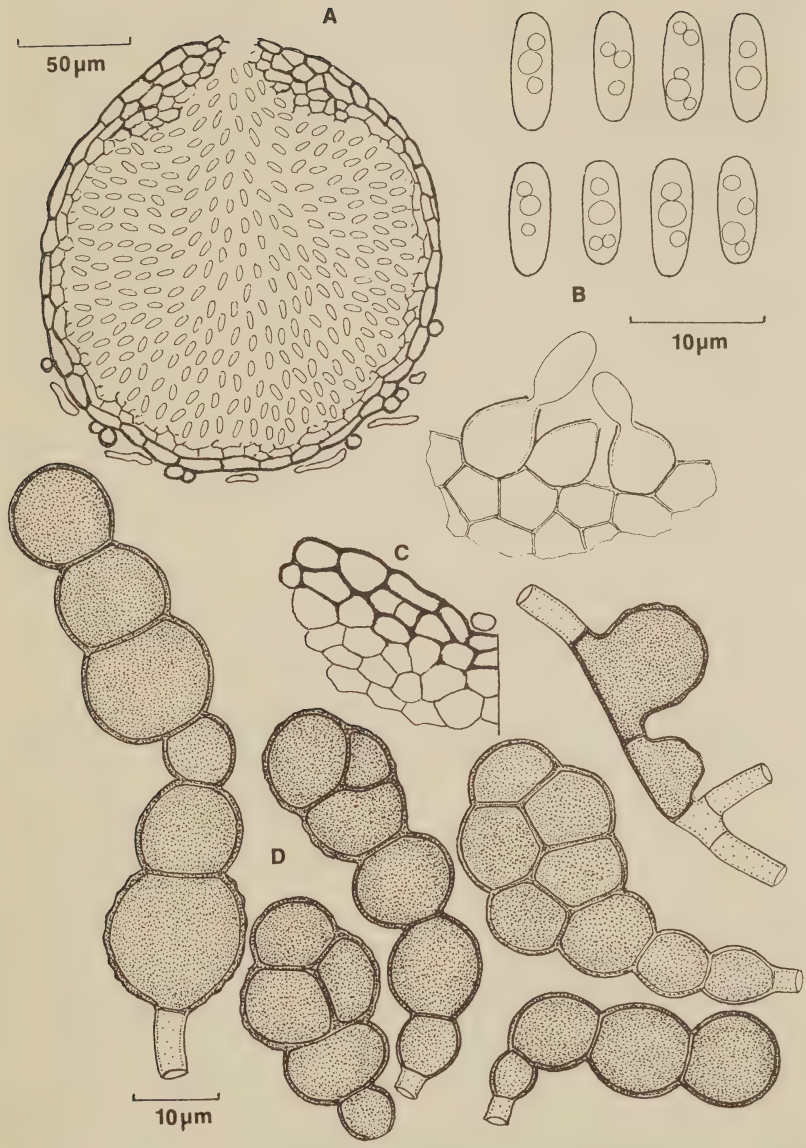
Collection examined: on *Polygonum tataricum* L., The Netherlands, 1964, G.H. Boerema, CBS 539.66, IMI 122266, ATCC 16791.

As with other *Phoma* species described thus far in this series of papers, a combination of characters serve to easily distinguish *P. pomorum*. Of particular importance are colony appearance on malt extract agar, the absence of a pycnidial neck, the configuration and shape of pycnidial wall cells and details of chlamydospore morphology. The chlamydospores bear some similarity to those of *Phoma sorghina* (Sacc.) Boerema, Dorenbosch et van Kesteren (see White and Morgan-Jones, 1983), but the two species are distinctly different in other features, notably colony color and appearance, and the presence of long pycnidial necks and inflated pycnidial wall cells in *P. sorghina*. Dictyochlamydospores of *P. americana* are different from those of *P. pomorum* in being generally thinner-walled and less pigmented. The colony characteristics of the two species on malt extract agar are widely different. Some chlamydospores produced by *P. pomorum* may somewhat resemble those of *Phoma glomerata* (Corda) Wollenw. et Hochapf. but the possession of chains of dictyochlamydospores which have a similar appearance to chains of *Alternaria* conidia by the latter serves to distinguish the two species.

ACKNOWLEDGMENT

We thank Dr. Richard T. Hanlin, Department of Plant Pathology, University of Georgia, Athens, for reviewing the manuscript.

FIGURE 1. A, vertical section of pycnidium; B, conidiophores and conidia; C, section through pycnidial wall cells in the vicinity of ostiole; D chlamydospores.


A
50µm
B
10µm
C
D
10µm

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MYCOTAXON

Vol. XXV, No. 2, pp. 467-468 April-June 1986

STUDIES IN TROPICAL CORTICIACEAE (BASIDIOMYCETES) VI

A new species of Steccherinum from Brazil

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Abstract

Steccherinum subochraceum is described to replace Irpex hydneus Rick ex Rambo (1959) which is a illegitimate name because the holotype was omitted in the original description.

STECCHERINUM SUBOCHRACEUM Bononi & Hjortst. spec. nov.

Species S. ochraceo affinis et valde similis sed differt sporis globosis 3.5(-4) um in diam. vel subglobosis 3.2-3.5 x 3.8-4 um.

Holotypus: Brazil. Sao Paulo State, Sao Paulo, State Park, "Fontes do Ipiranga" (Instituto de Botánica). 1966-10-06. Leg. Hugo Requejo (SP 97591).
Isotypus: (GB).

Fruitbody effuse, adnate or with revolute margin, in the type reflexed with the margin and subiculum much paler than the fertile aculeal part, margin 2-4 mm, smooth to more commonly byssoid or fimbriate. Hymenium distinctly odontioid, pale salmon-coloured, aculei conical, smooth, subulate, simple to more rarely crowded, about 4-5 per mm and 1-2(-3) mm long. Hyphal system dimitic, generative hyphae thin-walled, 2-2.5 um wide , with clamps, in the aculeal trama interwoven and mixed with skeletals which are 4-5 um wide and lacking clamps, solidly thick-walled, with walls somewhat swelling in KOH. Cystidia of two kinds; pseudocystidia often numerous in the aculei, rare or lacking in the subiculum, strongly encrusted as much as 10-20 um in the apical part, blunt to more rarely conical, hymenial cystidia in varying numbers, but especially

common in the middle part of the aculei, 30-40 um long, subconical and apically strongly encrusted, with a basal clamp. Basidia subclavate, slightly sinuous, 20-35 x 4.5-5 um, with four sterigmata and a basal clamp. Spores globose to more rarely subglobose, thin-walled, smooth, 3.5(-4) um in diam. or when subglobose about 3-3.5 x 3.5-4 um.

Remarks. Rambo (1959) described Irpex hydneus Rick but unfortunately the type specimen was not mentioned, consequently the name is illegitimate (Art.37). Geesteranus (1974) made a formal combination to Steccherinum and referred as holotype No. 22824 Brazil. Sao Salvador. 1945-04-04. J. Rick (PACA). A part of this specimen was found in SP and studied by us and shows the same characteristics as SP 97591. The latter is used as an holotype because it is much better preserved and is a relatively large specimen. A third specimen (SP 128128) from Sao Paulo, Cantareira is probably the same but no spores were found.
S. subochraceum is macroscopically similar to S. ochraceum (Pers.:Fr.) S.F. Gray. However, the spore-morphology is distinctive and together with the hymenial cystidia, which are absent in S. ochraceum, it will be sufficient to separate the two taxa. For comparison see Eriksson & al. 1984.

Acknowledgment

We thank Dr. Leif Ryvarden, University of Oslo, for his critical review of the manuscript.

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MYCOTAXON

Vol. XXV, No. 2, pp. 469-486 April-June 1986

TAXONOMY OF THE **FOMITOPSIS ROSEA** COMPLEX (APHYLLOPHORALES; POLYPORACEAE)

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SUMMARY

The species of **Fomitopsis rosea** complex comprise a group of fungi distributed worldwide, with some species more adapted to temperate regions and others to tropical ones. The new combination **Fomitopsis cupreo-rosea** is proposed. Therefore, seven species are included in this complex: **F. cajanderi, F. carnea, F. cupreo-rosea, F. dochmia, F. feei, F. lilacino-gilva,** and **F. rosea.** They share the following characteristics: rose-colored context, at least when young; annual or perennial basidi ocarp; trimitic hyphal system; hyaline, smooth-walled, cylindric to allantoid spores; no special structures in the hymenium (with exception of cystidioles reported for **F. cajanderi** and **F. dochmia**); and brown rot type of decay.

Members of the **Fomitopsis rosea** complex are of economic importance due to the decay losses they cause in living and dead trees and/or in wood in service. Tropical species are commonly found on hardwoods, especially dead trees or wood in service. Temperate species occur more commonly on conifers, in living or dead trees and wood in service. They all cause brown rots.

The classification of these fungi has been controversial and they have been placed in at least 4 different genera. The first classifications were based mainly on macroscopic characters of the basidiocarps and geographical distribution. Murrill (1908, 1915) recognized some of these fungi in the genus **Fomes** (Fr.) Kickx. These included **F. roseus** (Alb. & Schw.: Fr.) Cke., **F. sagraeanus** (Mont.) Murr., and **F. subferreus** Murr. **Fomes carneus** Cke. was considered by him to be a synonym of **F. roseus**, and he listed **Polyporus feei** Fr. as a questionable synonym of **Coriolus brachypus** (Lev.) Murr. Overholts (1914, 1921), making increased use of microscopic characters, pointed out the differences between **F. roseus** and **F. carneus** (**Trametes carnea** Blume & Nees), and stated that the two were so distinct that they must be regarded as separate species.

The confusion between **F. roseus** from North America and **T. carnea** described from Java remained until Weir (1923) clearly established the difference between them. To correct Berkeley's misuse of the name **Polyporus carneus** Fr. for a North American species in 1872, Weir renamed this taxon as **Trametes subrosea** (1923). **T. carnea** is considered in his paper as a synonym of **Polyporus rubidus** Berk. The similarity between basidiocarps of **T. subrosea** and **Trametes feei** (Fr.) Pat. is pointed out in his paper, but he noted that they can be distinguished based on characters of the pileus, size and shape of

University of Arizona Agricultural Exp. Sta. Journal Article 4140.

spores, the substrata and decay characteristics.

Further studies based on cultural characteristics confirmed the separati on of **F. roseus** and **T. subrosea** as distinct species. Snell, Hutchinson and Newton (1928) carried out temperature studies with various isolates of the two fungi, and reported an optimum of 30 C for **T. subrosea** and 26-28 C for **F. roseus.** Included also in this study was **T. feei** with an optimum of 28 C. They also studied the moisture requirements for the two fungi, and reported that **F. roseus** is more commonly found in drier substrates than **T. subrosea.** Mounce and Macrae (1937) carried out studies on sexuality of the two species. They found that monokaryons of the two species were not interfertile, and concluded that they can be positively considered different species. Nobles (1948) noted that **F. subroseus** produced chlamydospores in culture, but **F. roseus** did not. Overholts (1933) transferred **T. subrosea** to the genus **Fomes** and in his paper on Polyporaceae of Pennsylvania (1935) stressed the differences between **F. subroseus** and **F. roseus.** Bondartsev and Singer (1941) transferred **F. subroseus** and **F. roseus** to the genus **Fomitopsis** Karst.

Complete descriptions of **Fomes subroseus** and **Fomes roseus** are given by Baxter (1951) and Overholts (1953). Included in Baxter's paper are descriptions of **T. feei, T. sagraeana** Mont, **T. cupreo-rosea** (Berk.) Lloyd, and **T. lilacino-gilva** (Berk.) Lloyd. **T. cupreo-rosea** and **T. lilacino-gilva** were originally described by Berkeley in 1856 and 1839 respectively, under the genus **Polyporus** Mich.:Fr. and redescribed by Lloyd in 1915 in his Synopsis of the genus **Fomes** under the genus **Trametes** Fr. Lowe (1955), in his descriptions of temperate and tropical species of **Fomes** with context white to rose, included **F. subferreus,** which he placed in synonymy with **F. dochmius** (Berk. & Br.) Cke., **F. feei** (previously **Polyporus feei** Fr.), **F. roseus, F. sagraeanus,** and **F. subroseus.** He considered that these fungi formed a rather homogeneous group, separated from each other by the size of the pores, shape of spores, and the macromorphology of the basidiocarp. In his type studies of polypores described by Karsten (1956) and in his monograph of the genus **Fomes** (1957, Section IV), Lowe placed **F. subroseus** in synonymy with **F. cajanderi** Karst. Three other species, **F. fraxineus** (Bull.:Fr.) Cke., **F. rubritinctus** Murr., and **F. hemileucus** (Berk. & Curt.) Cke. were also included in this section. Lowe considered these three species unrelated to the other members and to each other, but sharing the color of the context. He suggested that the other species previously placed in **Trametes** form a well-marked group with many tropical relatives, which needed to be more thoroughly studied with particular reference to microscopic characters. He also noted that interrelations within this group were difficult to determine due to specimens commonly being sterile.

Kotlaba & Pouzar (1957), based on the work of Bondartsev and Singer (1941), placed **F. cajanderi** in the genus **Fomitopsis.** Cunningham (1965) in his book on New Zealand polypores, included **T. lilacino-gilva** and **T. feei** in the genus **Trametes,** and transferred **F. dochmius** to the genus **Osmoporus** Singer. M.E.P.K. Fidalgo (1968), in her study of some fungi collected in Mato Grosso, Brazil, included **T. cupreo-rosea** and pointed out the differences between this species and **F. feei.** She considered that the species described by Montagne as **P. sagraeanus** was **T. cupreo-rosea,** and that the description of **F. sagraeanus** given by Lowe (1957) was also based on a specimen of **T. cupreo-rosea.** In 1980, Ryvarden and Johansen, in their preliminary flora of East African Polypores, included **F. carnea** (Nees) Imaz. and **F. dochmia** in the genus **Fomitopsis** Karst. due to their annual or perennial basidiocarps, the presence of a hard crust and trimitic hyphal systems. **F. feei, T. lilacino-gilva,** and **T. cupreo-rosea** were included in **Trametes** because of their annual basidiocarps and trimitic hyphal systems. They also pointed out that **F. carnea** must be a

close relative of **F. rosea** and **F. cajanderi.**

Cultural descriptions of rose-colored polypores are given by Snell (**Fomes roseus**, 1922), Campbell (**F. roseus** and **F. subroseus**, 1938), Nobles (**F. roseus** and **F. cajanderi**, 1958, 1965), Stalpers (**F. roseus, F. cajanderi, T. lilacinogilva**, and **T. feei**, 1978), Van der Westhuizen (**F. cajanderi**, 1971), and Bakshi, Sen and Singh (1970) who described cultural characteristics of **F. dochmius** and **F. roseus** from India. Wright and Deschamps (1975) gave detailed macroscopic, microscopic, and cultural descriptions of **F. feei and T. lilacinogilva**, which they transferred to the genus **Fomitopsis.** Other descriptions of basidiocarps of some of these fungi have been given by Ito (1955), Bondartsev (1971), Domanski (1972), Reid (1973), Ryvarden (1976), Galvan Villanueva and Guzman (1977), Valenzuela, Guzman and Castillo (1981), Julich (1984), Gilbertson (1974), and Lindsey and Gilbertson (1978).

In this study, the inclusion of all these fungi in the genus **Fomitopsis** is proposed due to their following common characteristics: rose-colored context, at least when young; annual or perennial basidiocarp; trimitic hyphal system; hyaline, smooth-walled, cylindric to allantoid spores; no special structures in the hymenium (with exception of cystidioles reported on **F. cajanderi** and **F. dochmia**); and brown rot type of decay.

MATERIALS AND METHODS

Representative specimens of each species obtained from different Herbaria were examined. Specimens of 4 species were also observed and collected in the field by the authors (See list under each species). Free-hand sections were prepared from each specimen and mounted in 3% KOH to which a drop of aqueous phloxine was added, and in Melzer's reagent. Observations were done under a light microscope. All drawings of microscopic characters were made with the use of a camera lucida. Variations in basidiocarp morphology were encountered among specimens of the same species; consequently, the morphological description of basidiocarps of each species is based on the study of all specimens available, to include the range of characters encountered.

TAXONOMIC SECTION

Fomitopsis P. Karst., Medd. Soc. Fauna Fl. Fenn. 6:9, 1881

Basidiocarps perennial, occasionally annual, pileate, rarely resupinate, sessile or effused-reflexed, dimidiate to ungulate, often large, tough-fibrous to woody when dry; pileus surface often first slightly velvety but soon glabrous, usually sulcate, with a distinct crust; pore surface cream, brownish gray to pink, pores small, round, dissepiments often thick, entire; tubes almost concolorous with the pore surface, often stratified; context pale cream to brown or pink, fibrous to tough; hyphal system trimitic or dimitic (binding hyphae sometimes very difficult to find); generative hyphae clamped, hyaline and thin-walled, skeletal and binding hyphae hyaline to pale yellow, thick-walled, nonseptate; cystidia absent; basidiospores cylindrical to allantoid or ellipsoid, smooth, hyaline, thin-walled, negative in Melzer's reagent; causing a brown rot on conifers and hardwoods. Cosmopolitan genus.

Key to Species

1. Pores 1-3 per mm, becoming subdaedaleoid or sinuous-daedaleoid — **3. F. cupreo-rosea**
1. Pores 3-8 per mm, mostly circular to angular, in some cases becoming subdaedaleiod — **2**

	2.	Basidiospores allantoid, 4.0-8.0 (-8.5) x 1.5-2.5 (-3) um	3
	2.	Basidiospores ellipsoid to cylindrical, 4.0-11.0 x 1.5-5.0 um	4
3.		Widely distributed in the Northern Hemisphere; mainly on conifers, rarely on hardwoods	**1. F. cajanderi**
3.		Widely distributed in the Southern Hemisphere and North to Mexico and Japan; known only on hardwoods	**2. F. carnea**
	4.	Basidiospores 5.0-12 x 2.5-5.0 um, on hardwoods, reported only on Myrtaceae	**6. F. lilacino-gilva**
	4.	Basidiospores 4.0-8.5 x 1.5-4.0 um; on hardwoods and conifers	4
5.		Tropical species; known only on hardwoods	5
5.		Temperate species; mainly on conifers, rarely in hardwoods	**7. F. rosea**
	6.	Basidiocarp with a thick black crust when old	**4. F. dochmia**
	6.	Basidiocarp lacking a crust	**5. F. feei**

Description of Species

1. **FOMITOPSIS CAJANDERI** (Karst.) Kotl. & Pouz.
Ceska Mykol. 9:157, 1957.
Fomes cajanderi Karst., Fenska Vet.-Soc. Ofv. Forh. 46(11):8, 1904. **Trametes subrosea** Weir, Rhodora, 25:217, 1923. **Fomes subrosea** Overh., Penn. Agr. Exp. Sta. Tech. Bull. 316, 1935. **Fomitopsis subrosea** (Weir) Bond. & Sing., Ann. Mycol. 39:55, 1941. **Trametes carnea** Amer. aut., not **T. carnea** (Blume & Nees) Wettstein. **Trametes roseo-zonata** Lloyd, Mycol. Writ. 7:1144, f. 2182, 1922.

Basidiocarps annual, biennial or perennial, solitary or imbricate, sessile or effused-reflexed, coriaceous, corky, hard to rigid when dry; pileus applanate, conchate, pinkish brown, pinkish red or pinkish gray, darker close to the base, 1.6-17.0 x 1.1-13.5 x 0.1-4.5 cm, with a decurrent part up to 1.5 cm; upper surface finely velvety tomentose, becoming radially appressed fibrillose-rugulose to nearly glabrous when old, zonate, striate, sulcate, sometimes rough with minute tufts of short erect hairs, with protuberances or a hard brownish pink or black crust; margin light brown or pinkish, thin or thick, acute, entire, rounded or dentate; pore surface pinkish brown to reddish brown in age; pores slightly angular, round, 3.0-5.0 (-7.0) per mm, dissepiments entire; tubes concolorous with the pores, distinctly stratified, fibrillose, to corky, up to 12 mm long, 1-4 mm long each season, old tubes stuffed with white mycelium, sometimes with a dark line separating the tubes from the context; context indistinctly zonate with darker zones, concolorous, lighter or darker than the tubes, up to 1.5 cm thick, whitish pink, corky to fibrous, with a black reaction when touched with KOH.

Hyphal system trimitic; generative hyphae hyaline, with clamps, thin-walled, branching at or near the septa or unbranched, (1.5) 2.0-5.0 um in diam; skeletal hyphae thick-walled, yellowish brown, nonseptate, (1.5) 2.0-6.0 um in diam; binding hyphae thick-walled, hyaline, nonseptate, 2.0-4.0 um in diam.

Cystidioles fusoid, 12.5-14.5 x 3.0-4.0 um.

Basidia clavate or subclavate, 4-sterigmate, 12.0-20.0 (-25.0) x 4.0-6.0 um, with a basal clamp.

Basidiospores smooth-walled, hyaline, allantoid, apiculate, 4.0-8.0 x 1.5-2.5 µm, negative in Melzer's reagent.

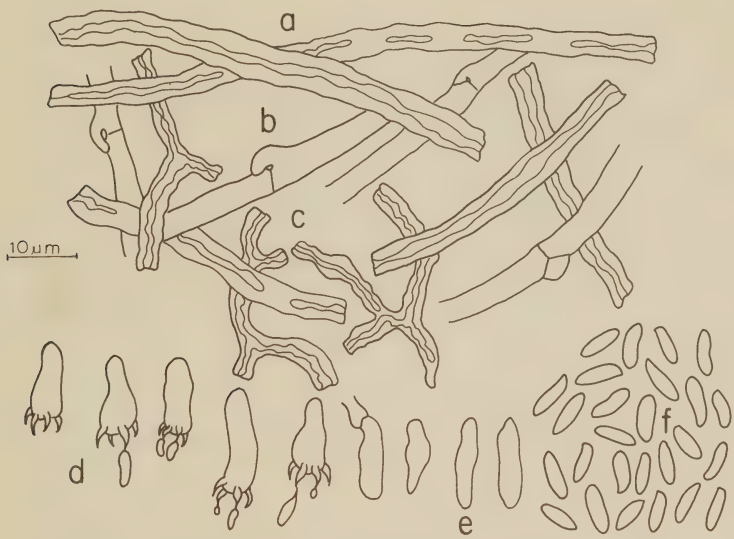

Fig. 1. **F. cajanderi** (JPL 325). a, skeletal hyphae; b, generative hypha; c, binding hyphae; d, basidia; e, cystidioles; f, basidiospores.

Type of rot: Brown cubical rot.
Substrata: On hardwood and conifer trees, mainly on conifers. Reported on Betulaceae; Salicaceae; Rosaceae; Ericaceae; Fagaceae; Pinaceae; Cupressaceae.
Distribution: Widely distributed in North America; Caribbean Islands; Asia; Europe and Russia.

Voucher specimens examined: CANADA: Alberta: Whitecourt, on **Picea mariana**, R.L. Gilbertson 6696 (ARIZ); Ontario: Petawawa Exp. Forest, B. & J. Eriksson 8822 (O); Newfoundland: Trout Brook, District of St. Georges, on **Abies balsamea**, R.L. Gilbertson 5372 (ARIZ); CHINA: Junlin Prov., Chang Bai, Shan Forest Reserve, Huang Song Pu, on **Larix olgensis**, L. Ryvarden 21571 (O); DOMINICAN REPUBLIC: On **Pinus occidentalis**, D.E. Etheridge 24 (ARIZ); MEXICO: Las Vigas a Las Lajas, Veracruz, on **Pinus sp.**, A. Lopez, L. Ryvarden 267 (ENCB); NEPAL: Khaptar, Etage Montagnard, J.F. Dohemez, L. Ryvarden (O); UNITED STATES: Arizona: Bear Wallow Santa Catalina Mts, Pima Country, on Douglas fir, J.C. Morse 8-83 (ARIZ); Mt. Graham, Pinaleno Mts, Graham County, on Douglas fir, J.C. Morse 11-83 (ARIZ); Rustler Park, Chiricahua Mts, Cochise County, on Douglas fir, J.C. Morse 159-83 (ARIZ); Minnesota: Lake Itasca State Park, Clearwater County, on **Picea sp.** R.L. Gilbertson 9453 (ARIZ); New York: Pack Forest, Warrensburg, on **Picea rubens**, R.L. Gilbertson 5801 (ARIZ).

Fig. 2. World distribution of **F. cajanderi.**

2. **FOMITOPSIS CARNEA** (Blume & Nees) Imaz.
Bull. Tokyo Sci. Mus. 6:92, 1943.
Fomes carneus Blume & Nees, Nov. Act. Acad. Caes. Leop. XIII:15, 1826.

Basidiocarps perennial, solitary or imbricate, effused-reflexed or sessile, woody when dry; pileus applanate, conchate, at first smoky pink, becoming brownish black with a definite black crust, up to 7 cm wide; resupinate portion up to 4 cm long and 1 cm deep; upper surface first tomentose and velvety, becoming glabrous, concentrically sulcate, azonate, with cracks; margin of lighter color, thin or thick, round or acute; pore surface pinkish brown or rosy with a lilac tint, margin sterile; pores round, 5.0-6.0 (-7.0) per mm, dissepiments entire and thick; tubes distinctly stratified, separated from each other by a white to pale pink thin layer, up to 3 mm thick, context brownish pink, corky to hard, slightly zonate, up to 1.7 cm thick, with a black reaction when touched with KOH.

Hyphal system trimitic; generative hyphae thin-walled, hyaline, with clamps, 2.0-4.0 (-5.0) um in diam; skeletal hyphae hyaline to yellowish brown, thick-walled, nonseptate, (3.0) 4.0-6.0 um in diam; binding hyphae light yellow, thick-walled, short-branched, 2.0-5.0 um in diam.

Cystidia or other sterile hymenial structures absent.

Basidia clavate, 4-sterigmate, 9.5-16.5 x 4.5-6.5 um; with a basal clamp.

Basidiospores cylindrical to slightly allantoid, smooth-walled, hyaline, 5.0-8.0 (-8.5) x (1.5) 2.0-2.5 (-3.0) um, negative in Melzer's reagent.

Type of rot: Brown cubical rot.

Substrata: On hardwood trees.

Distribution: Asia, Africa and Mexico.

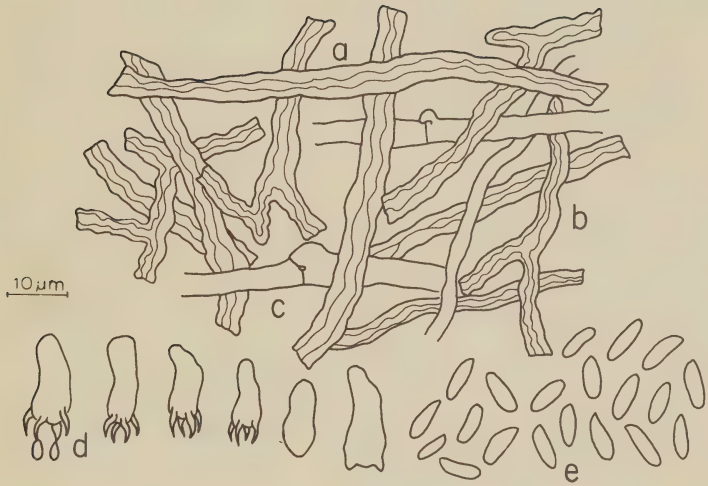

Fig. 3. **F. carnea** (O 10118). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

Fig. 4. World distribution of **F. carnea**.

Voucher specimens examined: MEXICO: El Parotal, Municipio Aguililla, Michoacan, X. Madrigal 2812 (ENCB). TANZANIA: Arusha Prov. Arusha Nat. Park, Mt. Meru, E. slope, 10118(0).

3. **FOMITOPSIS CUPREO-ROSEA** (Berk.) Carranza & Gilbn., , comb. nov. **Trametes cupreo-rosea** (Berk.) Lloyd, Mycol. Writ. 4 (Synop. **Fomes**) 226, 1915. **Polyporus cupreo-roseus** Berk., Hook. J. Bot. 8, 1856. **Microporus cupreo-roseus** (Berk.) Kuntze, Rev. Gen. Plant 3(3):495, 1898. **Polystictus cupreo-roseus** (Berk.) Cke., Grevillea 14(71):85, 1886. **Polystictus cupreo-vinosus** Berk. in Cke, Grevillea 14(71):85, 1886; Grevillea 15(73):23, 1886, nomen nudum.

Basidiocarps annual or perennial, solitary or imbricate, sessile or with a contracted base, dimidiate and broadly attached, with a resupinate poroid part frequently present, coriaceous to woody when dry; pileus applanate, conchate, laterally connate or ungulate, 5.0-16.5 x 2.6-10.3 x 0.3-2.5 cm, resupinate part up to 0.8-1.5 x 0.5 cm; upper surface brownish pink, grayish brown or grayish pink, first velvety, fibrillose, becoming glabrous when old, with a weak silky dull shine, weakly sulcate, radiate-striate, strongly zonate in variable shades, old specimens dotted with protuberances or warts close to the base; margin sharp, acute, thin, entire; pore surface pinkish brown or vinaceous, with a sterile margin up to 1.5 mm; pores round, angular or subdaedaleoid, becoming sinuous-daedaleoid, 1.0-3.0 per mm, dissepiments thick, entire; tubes concolorous with the pore surface, indistinctly stratified, up to 7 mm long, old tubes stuffed with white mycelium; context pinkish brown or darker than the pores, sometimes with a dark zone separating the tubes from the context,

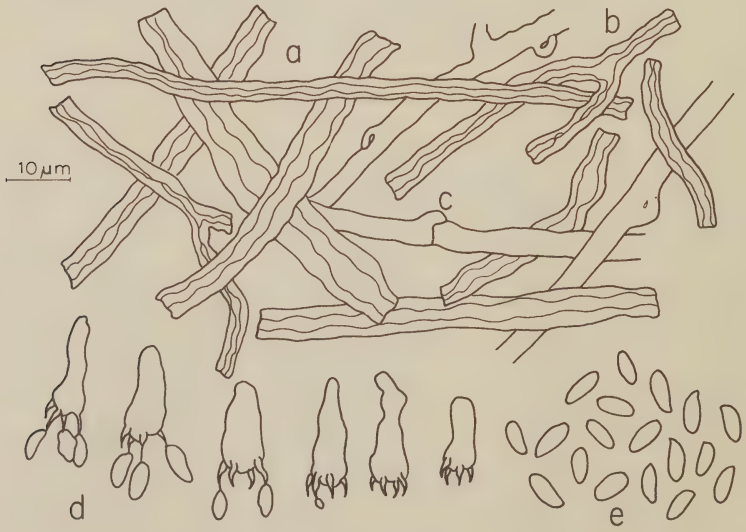

Fig. 5. **F. cupreo-rosea** (FH 66818). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

dense, fibrous, up to 1.9 cm thick, with a black or cherry red reaction when touched with KOH.

Hyphal system trimitic; generative hyphae with clamps, hyaline, thin to slightly thick-walled, occasionally branched, (1.5) 2.5-4.5 um in diam; skeletal hyphae yellowish brown or hyaline with a lilac shade, thick-walled, non-septate, (2.0) 2.5-8.0 um in diam; binding hyphae moderately branched, thick-walled (1.5) 3.0-4.0 um in diam.

Cystidia or other sterile hymenial structures absent.

Basidia clavate, 4-sterigmate, (9.0) 12.0-19.0 x 4.0-6.5 um, with a basal clamp.

Basidiospores cylindrical, hyaline, smooth-walled, 5.0-7.0 (-8.0) x (2.0) 2.5-3.5 um, negative in Melzer's reagent.

Type of rot: Brown cubical rot.

Substrata: On hardwood trees, very common on burned wood.

Distribution: Mexico, Central and South America; Caribbean Islands.

Fig. 6. World distribution of **F. cupreo-rosea.**

Voucher specimens examined: BRAZIL: St. Anna da Shapada, Humayta Madeira River, Matto Grosso, J.R. Weir and Malme 66818 (FH); BRITISH GUIANA: Bartica, R. Essequibo, D.H. Snider 599 (FH); COLOMBIA: Sierra de la Macarena, Rio Guapaza, Little 10238(0); COSTA RICA: Alto de las Palomas, Santa Ana, San Jose, on hardwood, J.C. Morse 14-81 (USJ); CUBA: (NY) No other data; MEXICO: Carretera Minatitlan, desv. Chinameca, Veracruz, San Pedro Soteapa, 203 (ENCB); PERU: Madre de Dios, Prov. Tambopata, Puerto Maldonado, Tambopata Nat. Res., P.J. Barbour 5007 (UL).

4. **FOMITOPSIS DOCHMIA** (Berk. & Br.) Ryv.
Norw. J. Bot. 19:231, 1972.
Fomes dochmius (Berk. & Br.) Cke., Grevillea 14:17, 1885. **Osmoporus dochmius** (Br.) G.H. Cunn., Polyp. New Zeal., N.Z. Dept. Scient. Ind. Res. Bull. 164, 1965. **Polyporus dochmius** Berk. & Br., Linn. Soc. Bot. J. 14:50, 1875. **Polyporus ferreus** Berk., Lond. J. Bot. 6:502, 1847. nom.

illegit. non Pers. 1825. **Fomes ferreus** Berk. : Cke., Grevillea 14:21, 1885. **Fomes subferreus** Murr., N. Amer. Fl. 9:97, 1908.

Basidiocarps annual, biennial or perennial, solitary or imbricate, sessile or effused-reflexed, dimidiate or attached by a lateral base, corky to woody when dry; pileus applanate, conchate or flabelliform, 3.0-12.0 x 2.0-15.0 x 0.6-3.0 cm; upper surface first brownish gray, becoming grayish black and with a distinct crust when old, glabrous, concentrically sulcate, radially wrinkled and cracked, creviced when old, faintly zoned, with some protuberances or warts close to the base; margin acute, thin, even, first velvety, becoming glabrous with narrow sulcate zones, ochraceous, brown or gray; pore surface pinkish gray, cream or tan when old, even, with a sterile border of 3.0-5.0 mm wide; pores round to subdaedaleoid, ochraceous pink or wood color, 5.0-8.0 per mm, dissepiments entire; tubes concolorous with the pore surface, indistinctly stratified, old tubes stuffed with white mycelium, up to 7 mm long; context ochraceous, pale pink, pinkish tan, or wood color, fibrous, up to 1.5 cm thick, sometimes darker than the pores, with a silky sheen and with a dark reaction when touched with KOH.

Hyphal system trimitic; generative hyphae with clamps, thin-walled, branched, hyaline, 2.0-4.0 um in diam; skeletal hyphae thick-walled, hyaline or yellowish brown, nonseptate, 3.0-7.0 um in diam; binding hyphae freely branched, thick-walled, branches tapering and tortuous, 2.0-5.0 um in diam.

Cystidia or other sterile hymenial structures absent, but reported by Bose (in Ryvarden and Johansen, 1980) to be clavate and finely encrusted. Lowe (1957) reported cystidioles 3.0-4.0 um in diam.

Basidia subclavate, or narrowly clavate, 4-sterigmate, 12.0-19.0 x 4.0-5.0 um, with a basal clamp.

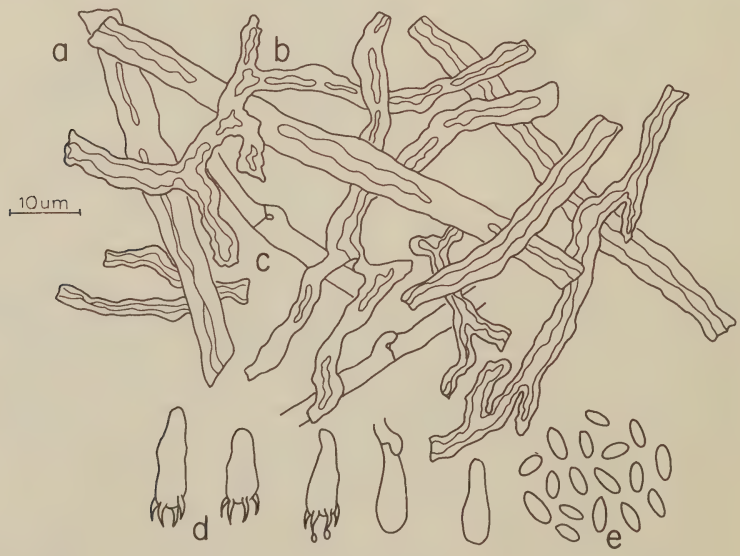

Fig. 7. **F. dochmia** (FH 4234). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

Basidiospores oblong-ellipsoid, smooth-walled, hyaline, 4.0-6.0 (-7.0) x (1.5) 2.0-2.5 um, negative in Melzer's reagent.
Type of rot: Brown cubical rot.
Substrata: On hardwood trees. Reported on Dipterocarpaceae (**Shorea robusta**) and Guttiferae (**Mesua ferrea**).
Distribution: Central and South America; Caribbean Islands, Asia and Australia.

Fig. 8. World distribution of **F. dochmia.**

Voucher specimens examined: BORNEO: Tawao, Elphinstone Prov., British North Borneo, 20618 USO 229569 (BPI). CUBA: Jaguey, Yateras Oriente W.P. Maxon 4234 (FH). ECUADOR: Canas, J.N. Rose, A. Pachans, G. Rose 23705 (FH) INDIA: Nalapani Forests, Dehra Dun on **Shorea robusta**, A. Hafizkan, USO 229242 (BPI). JAMAICA: A.E. Wright (FH). MALAYA: Johore, Danan Sadeli River, E. Corner (O). PHILIPPINES: Tawitania Island, Sulu Archipelago, H.S. Yates 36119, USO 229246 (BPI). SRI LANKA: USO229570 (BPI), No other data. THAILAND: Nakhaunsvi, Thamarat San Klang, Vee Hnoa, USO 229237 (BPI).

5. **FOMITOPSIS FEEI** (Fr.) Kreisel
Univ. Habana (Cuba), Ser. 4, Cienc. Biol. No 16:83, 1971.
Trametes feei (Fr.) Pat., Essai Taxon. p. 92, 1900. **Polyporus feei** Fr., Linnaea 5:518, 1830. **Fomes feei** (Fr.) Lowe, Mycologia 47:217, 1955. **Polyporus rubidus** Berk., Lond. J. Bot. 6:500, 1847. **Fomes sagraeanus** sensu Murrill non Mont., N. Am. Fl. 9(2):96, 1908. **Polystictus feei** (Fr.) Cke., Grevillea 14:82, 1886.

Basidiocarps annual, biennial or perennial, solitary or imbricate, sessile or effused-reflexed, with a contracted base, dimidiate, broadly attached, coriaceous-soft when fresh, corky to woody when dry; pileus applanate, conchate or flabelliform, frequently with a decurrent resupinate part, 2.8-20.0 x 2.1-10.0 x 0.4-3.0 cm; upper surface pale brown, pale brick red, grayish, pinkish brown, or dark brown, fading when drying, velutinate and soft to touch

when young, becoming glabrous in age with a dull weak shine, strongly or weakly zonate, more or less sulcate, somewhat radiate-striate, old specimens frequently dotted with protuberances or warts of lighter color close to the base; margin thin, acute, sharp, entire, 2-4 mm wide; pore surface pale pinkish brown, whitish pink, or ochraceous pink, margin narrow, sterile; pores round, (3.0) 4.0-7.0 (-8.0) per mm, dissepiments entire; tubes concolorous with the pore surface, indistinctly stratified in one, two or more layers, up to 8 mm long, old tubes stuffed with whitish mycelium; context concolorous with pore surface or darker, soft to corky, fibrous, up to 1 cm thick, faintly zonate, with a cherry red or black reaction when touched with KOH.

Hyphal system trimitic; generative hyphae with clamps, thin-walled, hyaline, 2-4 µm in diam, occasionally branched; skeletal hyphae yellowish brown, hyaline or with a pale shade of lilac, thick-walled, nonseptate, 2-6.6 µm in diam; binding hyphae moderately branched, thick-walled, 2-4.5 µm in diam.

Cystidia or other sterile hymenial structures absent.

Basidia clavate, 4-sterigmate, 10.0-20.7 x 3.6-7.0 µm, with a basal clamp.

Basidiospores cylindrical, hyaline, smooth-walled, somewhat pointed at the ends (4.0) 5.0-7.0 (-8) x (1.5) 2.0-3.5 (-4) µm, negative in Melzer's reagent.

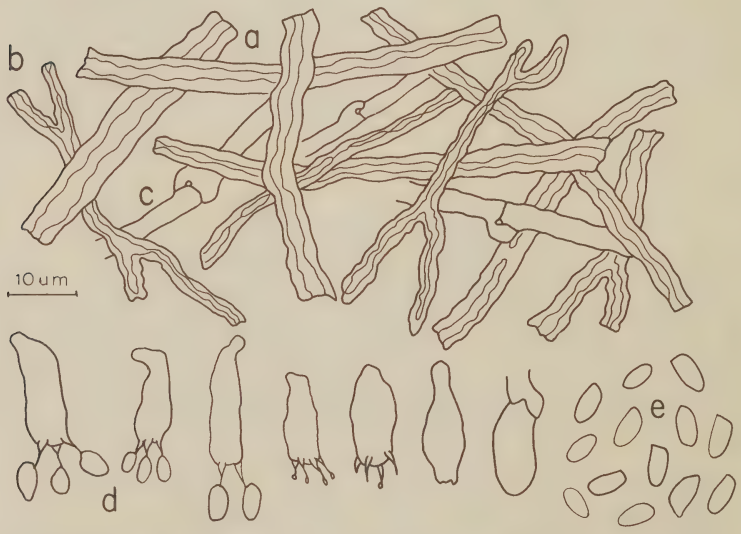

Fig. 9. **F. feei** (USJ 21261). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

Type of rot: Brown cubical rot.

Substrata: On dead hardwood trees, very common on burned wood. Reported on Leguminosae (**Piptadenia rigida; Lonchocarpus sp.**; Mimosaceae: **Acacia melanoxylon**); Myrtaceae (**Eucalyptus gummifera**); Anacardiaceae (**Schinopsis lorentzii**).

Distribution: North, Central and South America; Caribbean Islands; Asia; Australia and New Zealand.

Fig. 10. World distribution of **F. feei.**

Voucher specimens examined: ARGENTINA: Jujuy, Camino de Palma Sola a El Fuerte, on **Schinopsis lorentzii**, Cordo et al., J-175 (BAFC 23278); BOLIVIA: Bopi River Valley, O.E. White 294 (FH); BRAZIL: Km 55 Br. 317 SW of Rio Branco, on road to Xapuri, Acre, B. Lowy, S.R. Lourie and V.M. de Souza 522 Br (UL). BORNEO: (FH). No other data; COLOMBIA: Sierra Nevada de Sta. Marta, Depto Magdalena, Cerro Quemado Trail, G.W. Martin 3807 (NY); COSTA RICA: Terron Colorado, Alajuela, on hardwood, J.C. Morse 21261 (USJ); EL SALVADOR: Vicinity of La Union, Depto de La Union, USO 234591 (BPI); GUATEMALA: Depto Escuintla, along or near Rio Michatoya, Southwest of Escuintla, 89051 (BPI); MEXICO: 20 Km sur del Km 77 carretera Chetumal a Escarcega, Camino Tomas Garrido, Quintana Roo, G. Guzman 20935 (ENCB); NICARAGUA: Kellerman (BPI). No other data; PHILIPPINES: Negros, H.M. Curram 13749 (NY); THAILAND: Chanwat Chiang Doo, Doi Chiang, Doo Nat. Park, L. Ryvarden 17979 (O); VENEZUELA: Calabozo Orituce River, M. Gochfeld (NY).

6. **FOMITOPSIS LILACINO-GILVA** (Berk.) Wright & Desch.
Rev. Inv. Agrop. INTA. Buenos Aires (Arg.) serie V, Pat. Veg. Vol. XII, No. 3, p. 143, 1975.
Polyporus lilacino-gilvus Berk., Ann. Nat. Hist. 3:324, 1839; **Polystictus lilacino-gilvus** (Berk.) Cke., Grevillea 14:82, 1886; **Trametes lilacino-gilva** (Berk.) Lloyd, Synopsis **Fomes**, p. 226, 1915; **Trametes violaceus** Lloyd, Syn. Sect. Apus **Polyporus**, p. 342, 1915; **Trametes griseo-lilacina** van der Byl, S. Afr. J. Sci. 18:283, 1922; **Trametes rosea** Lloyd, Letter 59:5, 1915.

Basidiocarps annual, biennial or perennial, solitary or imbricate, dimidiate, broadly attached or with a lateral base, corky to woody when dry; pileus applanate, conchate or ungulate, 2.0-20.0 x 2.0-9.0 x 0.5-10.0 cm with a decurrent resupinate poroid part up to 3.0 x 0.2 x 0.1 cm; upper surface straw color, tan, bay, grayish or pinkish brown, darker when old, concentrically sulcate and ridged, strongly radiate-striate, strigose or setulose, becoming

glabrous when old, strongly zonate, old specimens with some protuberances or warts near the base; margin velutinate, sharp to round, entire; pore surface rose pink, pinkish brown, violaceous lilac or pallid ferruginous, margin wide, sterile up to 3.0 mm; pores round, angular or some slightly labyrinthiform, (2) 3.0-5.0 (-6.0) per mm; tubes concolorous or pinkish white, faintly zonate, up to 8.0 mm long; context rose, lilac, or pinkish brown, or concolorous with the pore surface, dense, fibrous, zonate up to 0.7 cm thick, dark or reddish brown reaction when touched with KOH.

Hyphal system trimitic; generative hyphae with clamps, branched, hyaline, thin-walled, 1-4 µm in diam; skeletal hyphae yellowish brown, thick-walled, nonseptate, 2.5-7.0 µm in diam; binding hyphae nonseptate, freely branched, branches tapering and tortuous, thick-walled, 2-5 µm in diam.

Cystidia or other sterile hymenial structures absent.

Basidia subclavate, 4-sterigmate, 12.0-23.0 x 4.0-8.5 µm, with a basal clamp.

Basidiospores elliptical, hyaline, smooth-walled, apiculate, 5.0-12.0 x 2.5-5.0 µm, negative in Melzer's reagent.

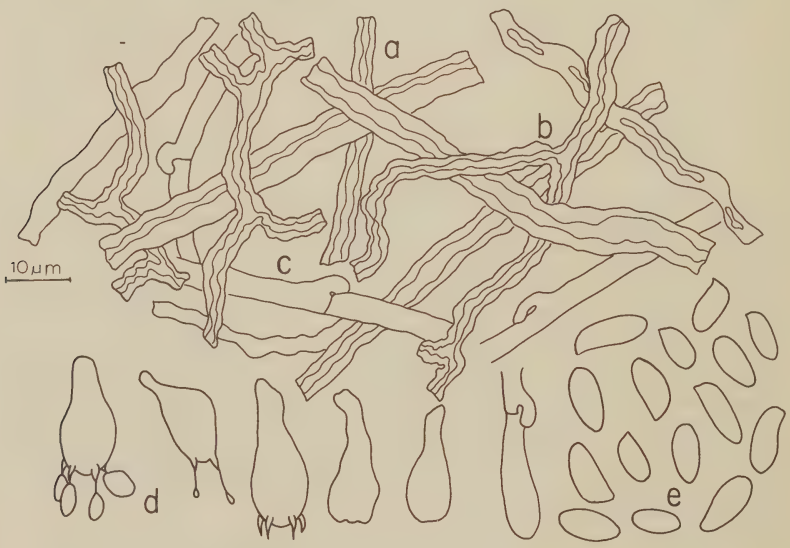

Fig. 11. **F. lilacino-gilva** (DC 9-79). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

Type of rot: Brown cubical rot.

Substrata: On decorticated hardwood trees, often on charred wood, worked timber, power poles and railway sleepers. Reported on Myrtaceae (**Eucalyptus calophylla, E. viminalis; E. globulus; Eucalyptus sp.; Tristania conferta**).

Distribution: South America; Australia; New Zealand; South Africa and Tasmania.

Voucher specimens examined: ARGENTINA: Rios Palmar de Colen, D. Cabral (O); AUSTRALIA: N.S.W. Whean Whean State Forest, J. Parker 3, DAR 35161 (O).

Fig. 12. World distribution of **F. lilacino-gilva.**

7. **FOMITOPSIS ROSEA** (Alb. & Schw.:Fr.) Karst..
Krit. Ofv. Finl. Basidsv. 306, 1889.
Boletus roseus Alb. & Schw., Consp. Fung., p. 251, 1805. **Fomes roseus** (Alb. & Schw.:Fr.) Karst., Soc. Fauna Fl. Fenn. Meddel. 5:39, 1879. **Trametes rosea** Karst., Hattsv. 2:47, 1882. **Polyporus roseus** (Alb. & Schw.) Fr., Syst. Mycol. 1:372, 1821.

Basidiocarps annual, biennial or perennial, solitary or imbricate, sessile, corky to woody when dry; pileus ungulate, conchate, applanate, with a resupinate part, 1.0-7.0 x 1.5-10.0 x 0.1-3.0 cm; upper surface pinkish brown, pinkish red, grayish brown, zonate, striate, concentrically sulcate, older parts often irregularly cracked, first very minutely tomentose, soon glabrous, sometimes slightly incrusted, with a thick rimose crust, brown to blackish in old specimens; margin undulate, acute, obtuse or rounded, thin, entire, remaining pinkish brown or lighter than the rest of the pileus; pore surface pinkish brown at first, then brown on old specimens; pores circular or subanglular, 3.0-5.0 (-6.0) per mm, dissepiments entire, thick with obtuse edges; tubes 0.5-4.0 (-5.0) mm long each season, rather distinctly to indistinctly stratified in old specimens, pinkish buff to gray, when old stuffed with white mycelium; context indistinctly zonate, white to pinkish gray or darker, compact, soft fibrillose, corky to rather hard, 0.2-1.0 cm thick, with a dark reaction when touched with KOH.

Hyphal system trimitic; generative hyphae with clamps, thin-walled, hyaline, 3.0-5.0 µm in diam; skeletal hyphae thick-walled to subsolid, pale brown to yellowish, nonseptate, 2.0-6.5 (-7.0) µm in diam; binding hyphae rather coarse, solid or nearly so, hyaline, with short branches or sometimes merely short processes, 3.0-5.5 µm in diam.

Cystidia or other sterile hymenial structures absent.

Basidia clavate, rounded, 4-sterigmate, 10.0-19.5 x 4.0-7.5 (-8.0)µm, with a basal clamp.

Basidiospores oblong, ellipsoid or almost cylindric, hyaline, smooth-walled, (5.0) 6.0-8.5 x (2.0) 2.5-3.5 (-4.0) µm, negative in Melzer's reagent.

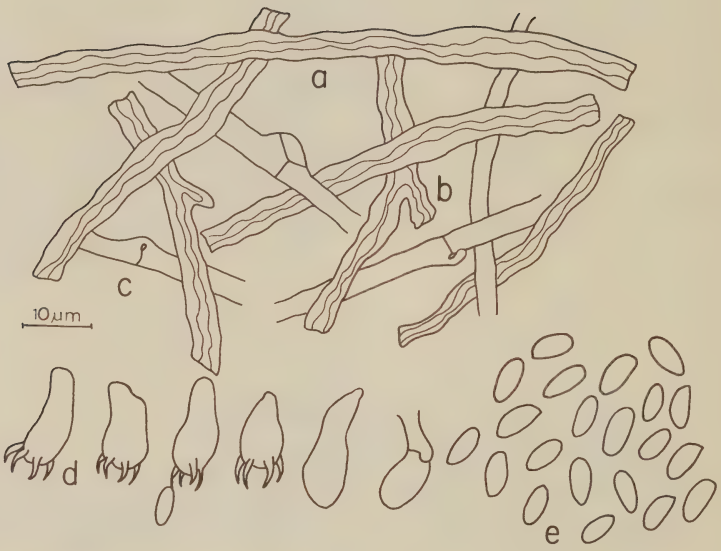

Fig. 13. **F. rosea** (RLG 6954). a, skeletal hyphae; b, binding hypha; c, generative hypha; d, basidia; e, basidiospores.

Type of rot: Brown cubical rot.
Substrata: On conifer and hardwood trees, mainly on conifers. Reported on Platanaceae; Ulmaceae, Pinaceae, and Salicaceae.
Distribution: North America; Asia; Europe and Russia. **Fomitopsis rosea** is distributed in northern latitudes or at high elevations from mixed conifer to spruce-fir forest zones.

Voucher specimens examined: CANADA: Dawson City, Yukon Territory, on **Picea glauca.** R.L. Gilbertson 8782 (ARIZ); FINLAND: Pera-Pohjanmaa, Tervola, Pisavaara Nat. Park, Liljalakie on **Picea abies,** H. Kotiranta & T. Niemela 1313 (ARIZ); MEXICO: Bosque de Chapultepec, 30 Km sur El Alto, Durango, on **Pseudotsuga menziesii.** G. Guzman, S. de la Campa 3502-A (ENCB); UNITED STATES: Arizona, Fort Apache Indian Reservation, Paradise Park, White Mts., Apache County on **Populus tremuloides.** R.L. Gilbertson 6954 (ARIZ); Soldier Creek, Pinaleno Mts. Coronado Nat. Forest, Graham County on **Populus tremuloides.** R.L. Gilbertson 10109 (ARIZ); Soldier Creek, Pinaleno Mts, Coronado Nat. Forest, Graham County on **Picea engelmannii,** R.L. Gilbertson 9083 (ARIZ); Montana: Flathead Lake, U of Montana Bio. Sta. on **Larix occidentalis.** R.L. Gilbertson 5929 (ARIZ); North Carolina: Indian Gap, Great Smoky Mountain Nat. Park, on **Picea rubens.** J.L. Lowe & R.L. Gilbertson 11071 (ARIZ); New York: Wolf Lake, on **Picea rubens.** R.L. Gilbertson 3762 (ARIZ); Washington: Olympic Peninsula, White Plains, on conifer. J.L. Lowe & R.L. Gilbertson 10493 (ARIZ).

Fig. 14. World distribution of **F. rosea.**

ACKNOWLEDGMENTS

We thank the following Herbaria for loaning the specimens examined: Farlow Herbarium Library, Harvard University, Cambridge, MA (FH); New York Botanical Garden, Bronx, NY (NYBG); National Fungus Collection, Beltsville, MD (BPI); University of Oslo Herbarium, Oslo, Norway (O); Herbario Escuela Nac. Ciencias Biologicas, Mexico (ENCB); Herbario Do Estado Maria Eneyda, P. Kauffmann, Sao Paulo, Brazil (SP); Herbario Facultad de Ciencias, Buenos Aires, Argentina (BAFC); Tulane University Herbarium, New Orleans, LA (TU); Louisiana State University Herbarium, Baton Rouge, LA (UL); Herbario Universidad de Costa Rica, Escuela de Biologia, San Pedro, Costa Rica (USJ). This paper is part of a Ph.D. dissertation submitted to the University of Arizona. This research was supported by Conicit, San Jose, Costa Rica.

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MYCOTAXON

Vol. XXV, No. 2, pp. 487-491 April-June 1986

OBSERVATION D'UN *TAPHRINA* PARASITE SUR *POLYSTICHUM SETIFERUM* (Forskall) Moore ex Woynar EN FRANCE

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RESUME

Un *Taphrina* a été récolté en France, dans le Cotentin, sur *Polystichum setiferum* (Forskall) Moore ex Woynar. Il détermine sur les feuilles de petites taches décolorées, non épaissies ni cloquées. Le mycélium est uniquement sous-cuticulaire. Les asques sont pourvus d'une cellule-pied. Ce champignon paraît très proche de *Taphrina polystichi* Mix, parasite sur *Polystichum acrostichoides* (Michx.) Schott en Amérique du Nord.

SUMMARY

A *Taphrina* has been collected in France, in the Cotentin, on *Polystichum setiferum* (Forskall) Moore ex Woynar. It produces small yellowish unthickened spots, without curling, on the leaves. The mycelium grows only beneath the cuticle. The asci are provided with a stalk cell. This fungus seems very close to *Taphrina Polystichi* Mix, parasite on *Polystichum acrostichoides* (Michx.) Schott in North America.

Parmi les espèces de *Taphrina* connues s'attaquant aux Filicinées, aucune jusqu'à présent ne semble avoir été décrite sur *Polystichum setiferum* (1). Cependant, au cours de deux années différentes, nous avons eu l'occasion d'observer sur cette Fougère la présence d'un parasite appartenant à ce genre d'Ascomycètes. Les récoltes ont été effectuées au mois de juillet, dans le Cotentin, le long d'un chemin creux très ombragé, situé près de la route menant de Valognes à Périers, sur la commune de St Jores. Le champignon, bien que très abondant dans ce lieu, n'a pas été retrouvé dans diverses autres localités visitées de la même région.

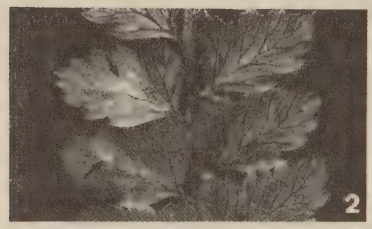
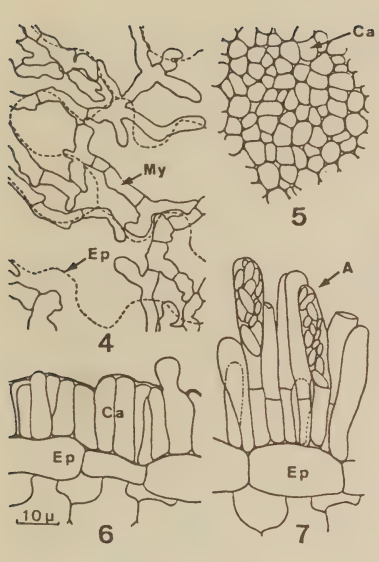
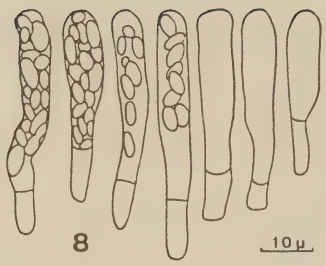


FIG. 1. Pinnules de *Polystichum setiferum*, vues par la face supérieure, portant des lésions dûes à une attaque de *Taphrina* (x 2,25). A, jeune tache décolorée. B, deux taches montrant un début de nécrose. FIG. 2. Jeunes taches (flèches) vues à la face inférieure de deux pinnules (x 2,25). FIG. 3. Portion de fronde portant de nombreuses petites taches nécrosées, résultant de l'attaque du champignon (grandeur nature).

OBSERVATIONS MACROSCOPIQUES

Les symptômes provoqués par le parasite sont au début très discrets. Ils consistent en de petites taches légèrement décolorées, dont le diamètre est le plus souvent inférieur à 2 mm, et dépasse rarement 3 mm, sauf par coalescence, de sorte qu'une même pinnule peut en porter plusieurs (Fig. 1). A leur niveau le limbe n'est ni épaissi ni boursoufflé. Les plus jeunes taches ont, sur l'une des faces (le plus souvent la face inférieure), une couleur blanchâtre, mate, caractéristique de la présence d'un mycélium sous-cuticulaire de *Taphrina* (Fig. 2). Le développement des cellules ascogènes se traduit par un soulèvement, visible à la loupe, de la surface des taches. Lorsque les asques ont rompu la cuticule, la pellicule blanchâtre fait place à un revêtement incolore, d'aspect légèrement muqueux. Ensuite les vieilles lésions deviennent brunes, et parfois se perforent. Certaines frondes peuvent être ainsi fortement altérées par suite de la présence de très nombreuses petites taches nécrosées (Fig. 3).





A, asques. Ca, cellules ascogènes. Cp, cellules-pied. Ep, cellules épidermiques; contours figurés en trait discontinu sur la FIG. 4. My, mycélium.

FIGS. 4 à 7. Différentes étapes du développement du champignon. 4, mycélium sous-cuticulaire. 5 et 6, cellules ascogènes. 7, asques à divers stades de maturité. 4 et 5, vues superficielles. 6 et 7, coupes transversales. FIG. 8. Exemples d'asques.

OBSERVATIONS MICROSCOPIQUES

Le champignon se développe uniquement sous la cuticule. Le mycélium suit d'abord plus ou moins le contour des cellules épidermiques; il est formé d'articles allongés, de diamètre régulier ou légèrement variqueux (Fig. 4). Il subit ensuite une intense ramification, tandis qu'il se recloisonne en articles courts qui deviennent les cellules ascogènes. Celles-ci s'étendent en une nappe continue à la surface des cellules épidermiques (Fig. 5 et 6).

Les septa mycéliens semblent dépourvus du disque présent chez beaucoup d'espèces de *Taphrina*. Ils ne possèdent pas de bouton central et d'autre part il n'apparaît jamais de délaminations (2).

Les asques mûrs possèdent une cellule-pied (Fig 7). Celle-ci est cylindrique ou légèrement conique, tronquée ou arrondie à la base, plus longue que large (Fig. 8). Dans chaque asque se différencient huit ascospores qui peuvent bourgeonner abondamment avant leur expulsion. Des mesures effectuées à partir des deux récoltes (notées ci-dessous A et B), sur une centaine d'asques à chaque

fois, ont donné les valeurs suivantes, en µm (les moyennes calculées sont indiquées entre parenthèses):

Asques - A: 21-53 (31,6) x 5-11 (7,3). B: 21-47 (33,4) x 5-10 (7,1).
Cellules-pied - A: 5-17 (10,4) x 4-8 (5,2). B: 3-18 (10,4) x 3-7 (5,1).
Ascospores: 3-6 x 2-4.

ESSAI D'IDENTIFICATION

Selon la monographie de Mix (1), le mycélium des espèces de *Taphrina* parasites sur Fougères peut adopter quatre types de disposition: uniquement sous-cuticulaire, intercellulaire et sous-cuticulaire, uniquement intercellulaire, et enfin intrapariétale. L'espèce que nous avons observée appartient à la première catégorie. Dans celle-ci Mix en range six, dont cinq sont, comme la nôtre, pourvues d'une cellule-pied. Parmi ces cinq, l'une, *T. faulliana* Mix, parasite en Amérique du Nord un *Polystichum*, *P. munitum* (Kaulf.) Presl., mais les longueurs des asques (43-76 µm) et des cellules-pied (13-33 µm) sont nettement supérieures à celles que nous avons mesurées. Les quatre autres sont connues en Europe. Deux de celles-ci, *T. athyrii* Siem. et *T. hiratsukae* Nishida, occasionnent sur diverses Fougères de petites taches non épaissies, semblables à celles que nous décrivons, mais leurs asques et leurs cellules-pied ont des longueurs nettement plus faibles que chez notre espèce: respectivement 13-17 et 13-30 µm pour les asques, et 4,5-8 et 4-10 µm pour les cellules-pied. Les deux restantes, *T. fusca* et *vestergrenii* Giesenhag., provoquent des déformations en forme de cloques sur les frondes de plusieurs espèces de *Dryopteris* . La première a, par rapport à notre champignon, des asques plus courts (19-27 µm) et des cellules-pied plus longues (15-34 µm). La seconde présente des dimensions plus proches mais cependant encore quelque peu différentes; ci-après les valeurs, en µm, données par Mix (A) et celles que nous avons relevées nous-même à partir d'échantillons récoltés, en Ecosse, sur *Dryopteris filix mas* Schott (B):

Asques - A: 23-50 x 6-10. B: 24-49 (36) x 6-16 (10,8).
Cellules-pied - A: 10-23 x 4-10. B: 9-32 (17,4) x 4-13 (7,5)
Ascospores - A: 3,5-6 x 2,5-4. B: 5-8,5 x 3-4.

Les asques de *T. vestergrenii* ont une longueur semblable à celle des asques du parasite de *Polystichum setiferum*, mais ils sont plus larges d'après nos mensurations. Les cellules-pied sont à la fois plus larges et plus longues. Selon nous les ascospores sont aussi plus grandes.

Ces différences de dimensions, jointes à l'aspect différent des symptômes, nous conduisent à distinguer notre champignon de *T. vestergrenii*.

Parmi les espèces possédant d'autres types de disposition qu'une localisation purement sous-cuticulaire, Mix en signale deux sur *Polystichum* déterminant des symptômes comparables à ceux que nous décrivons, à savoir des taches non accompagnées de la formation de cloques : *T. wettsteiniana* Herzf. sur *P. lonchitis* (L.) Roth et *T. polystichi* Mix sur *P. acrostichoides* (Michx.) Schott. Il attribue à toutes les deux un mycélium à la fois intercellulaire et sous-cuticulaire. Chez *T. wettsteiniana* les dimensions de l'asque sont dans les limites de celles que nous avons mesurées (25-38 x 6-10 µm) ainsi que celles de la cellule-pied (6-13 x 5-8 µm), mais la présence de cette dernière n'est pas constante, alors que tous les asques que nous avons observés sur *Polystichum setiferum* en possédaient une. Par contre, chez *T. polystichi* les asques sont toujours supportés par une cellule-pied; les dimensions qu'en donne Mix sont comparables à celles des asques de notre champignon (23-53 x 4,5-8,5 µm). Nous avons eu l'occasion d'observer un échantillon de cette espèce, conservé dans l'herbier du Muséum National d'Histoire Naturelle de Paris (portant la référence: Sydow 1005). Nous n'avons pas décelé la présence d'un mycélium intercellulaire, contrairement à ce qu'indique Mix. Ce *Taphrina* semble donc très voisin de celui que nous avons récolté. D'après les mensurations de Mix il s'en différencierait toutefois par la longueur plus importante des cellules-pied (13-23 µm). Il faut aussi noter que les taches peuvent atteindre un plus grand diamètre (jusqu'à 1 cm), mais ceci pourrait être dû à la différence d'hôte, les pinnules de *Polystichum acrostichoides* étant beaucoup plus grandes que celles de *Polystichum setiferum*. Une étude comparative de souches isolées à partir des deux Fougères serait souhaitable, ainsi que des expériences d'inoculation, avant de décider si les deux parasites appartiennent ou non à la même espèce.

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MYCOTAXON

Vol. XXV, No. 2, pp. 493-503 April-June 1986

THYREA POLYGLOSSA and THYREA DIVERGENS sp. nov.

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SUMMARY

Thyrea polyglossa (Nyl.) Zahlbr. is reported from Mexico. Information on the apothecia and pycnidia is given for the first time. A new species, Thyrea divergens Henssen, is described from Kenya. It is closely related to T. polyglossa, from which it differs in having erect, much-branched lobes with divergent tips. The relationship with other species of the genus is discussed.

INTRODUCTION

Thyrea polyglossa (Nyl.) Zahlbr. was described by Nylander (1876) from a sterile specimen collected by Wright in Cuba. In Mexico we found a rosette-shaped, fertile lichen which corresponded well to the original collection of T. polyglossa, and it enables us to provide a description of the fruiting structures.

An undescribed Thyrea species from Kenya, kindly sent to us by Dr. Swinscow, was found to be closely related to T. polyglossa; the new species is named here T. divergens. The two species differ in some characteristic features from the type species, T. plectospora Mass. and other species of the genus.

MATERIAL AND METHODS

The herbarium abbreviations follow Index Herbariorum. - Freezing microtome sections were embedded in lactophenol cotton-blue (LPCB). For studying the iodine reaction Lugol's solution was added without pretreatment. For habit photographs a Wild M 7 dissecting microscope was used, and for

anatomical structures a Wild M 20 microscope. The measurements given refer to preparations in LPCB, or air dried material.

DESCRIPTIONS

Thyrea polyglossa (Nyl.) Zahlbr. 1924 p.808
Omphalaria polyglossa Nyl. (1876 p.558). Typus: Cuba, Wright, Lichenes Cubenses Ser. II. 47 (H: hb. Nylander 42671-lectotypus, here chosen; G, UPS-iso-lectotypi).

Further specimens examined: Mona Island near Puerto Rico, on exposed limestone, 1914, Britton et al. 1850 (MICH: no. 12420 and 13440).- Mexico, Hidalgo, Metztitlán, in seepage lines of NW exposed, vertical limestone faces along roadside at 1350 m, 1982 Henssen & Vobis 28734c (MB).

Figs 1A-D, 2A-E, 3F
Thallus blackish in flat rosettes 8-13(-17) mm wide, deeply divided into lobes, attached by a central umbilicus. Lobes flat, tongue-shaped or angular, furrowed on under side, 0.6-1.2(-1.6) mm wide, furcately branched at tip, bearing 0.05-0.2 mm long isidia or small lobules. Thallus (in section) 400-600(-1000) µm thick, heteromerous, algal zone 35-70 µm thick. Hyphae lying horizontally in thallus centre, perpendicularly towards margin; hyphal cells in thallus centre long, cylindrical, 1.5-2.5 µm thick, below and within algal zone short and enlarged to 3.5-8 µm, haustoria globose or finger-like (Figs 2B-E, 3F). Phycobiont probably a member of the Pleurocapsales, cells singly or in pairs, 4.5-8(-12) µm diam.

Apothecia marginal, submarginal or laminal on ridges, 0.25 -0.6 mm diam., constricted at base, thalline margin c. 0.1 mm thick, disc brown. Hymenium 130-140 µm high, hymenial gelatin deep blue in iodine, hypothecium 20-40 µm high, excipulum proprium 45-70 µm high, restricted to base of apothecium, composed of loosely interwoven hyphae elongated into a stipe. Asci cylindrical, 60-70 x 11-12 µm (immature), with 8 or fewer spores. Spores simple, colourless, ellipsoid, ovoid or curved, 9.5-14 x 4.5-9.5 (immature). Pycnidia c. 0.25 µm broad, wall convoluted, conidia short fusiform, 2.5-4 x 1 µm, produced terminally by elongated conidiogenous cells.

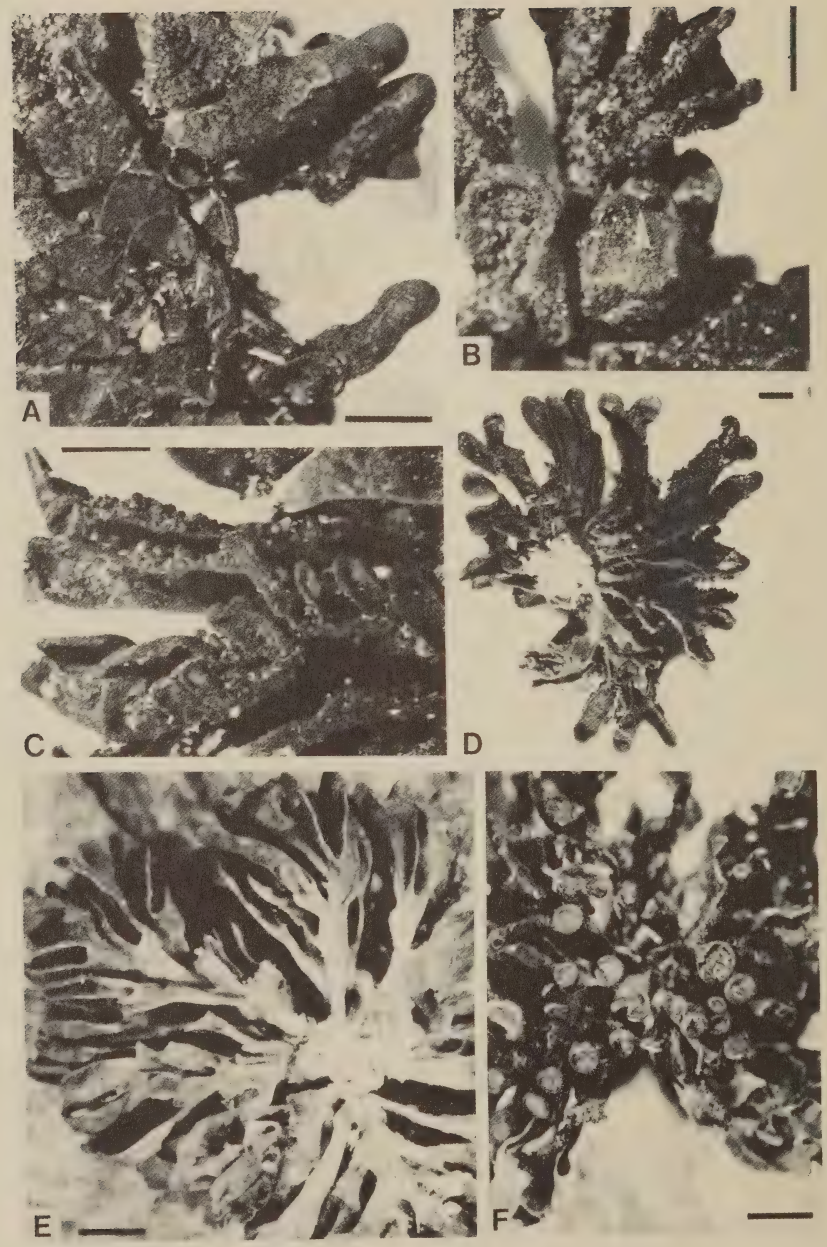
Ecology and distribution. T. polyglossa grows in seepage lines on calcareous rock. The lichen has been collected so far in Mexico, Cuba and Mona Island near Puerto Rico.

Remarks. In the material from Cuba and Mona Island the lobes are mainly flat and tongue-shaped (Fig. 1D), while in the Mexican specimen they are angular and more deeply furrowed on the under side; lobules are conspicuously developed in the type material (Fig. 1C). The isidia in the type collection may have a depressed tip, thus simulating apothecia, but no apothecia or pycnidia were found when the type and the lichen from Mona Island were reexamined. In the Mexican specimen both juvenile and large apothecia contained only badly developed asci and spores. In T. polyglossa a distinct excipulum proprium is not developed but replaced by a cone-shaped web of loosely interwoven hyphae below the hypothecium (Fig. 1A, D).
The phycobiont is probably a species of Chroococcidiopsis or Myxosarcina, genera of the Pleurocapsales which recently have been recognized as symbiotic algae in Lichinaceae (Büdel & Henssen 1983, Büdel 1985); this assumption, however, needs to be verified by culture experiments.

T. polyglossa is characterized by deeply divided, flat, rosette-shaped thalli with narrow lobes bearing large isidia, and an excipulum restricted to a basal hyphal web. A heteromerous thallus, composed of horizontally lying thin hyphae in the central part, and perpendicularly arranged large-celled hyphae in the marginal part, is a characteristic feature which T. polyglossa has in common with the new species T. divergens.

T. rotundata Büdel et al. is similar in habit but differs having laminal apothecia, non-isidiate lobes, and in the anatomy of the thallus. In this species the hyphae form a reticulum in the marginal part; in addition the algal cells are smaller and clustered in packets of four to eight (Henssen et al. 1985).

T. pulvinata (Schaer.) Mass., which also has a rosette-shaped, deeply divided thallus, differs in having erect, thick and wide lobes with a rather uniform net of thin hyphae, small, clustered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algal cells, and a hymenium surrounded by a cup-shaped excipulum proprium composed of parallel hyphae. T. plectospora corresponds in the anatomy of its thallus and apothecium to T. pulvinata but has an orbicular thallus which is not deeply divided into lobes and laminal, immersed apothecia (cf. Henssen 1979, Figs 4H, 6E).

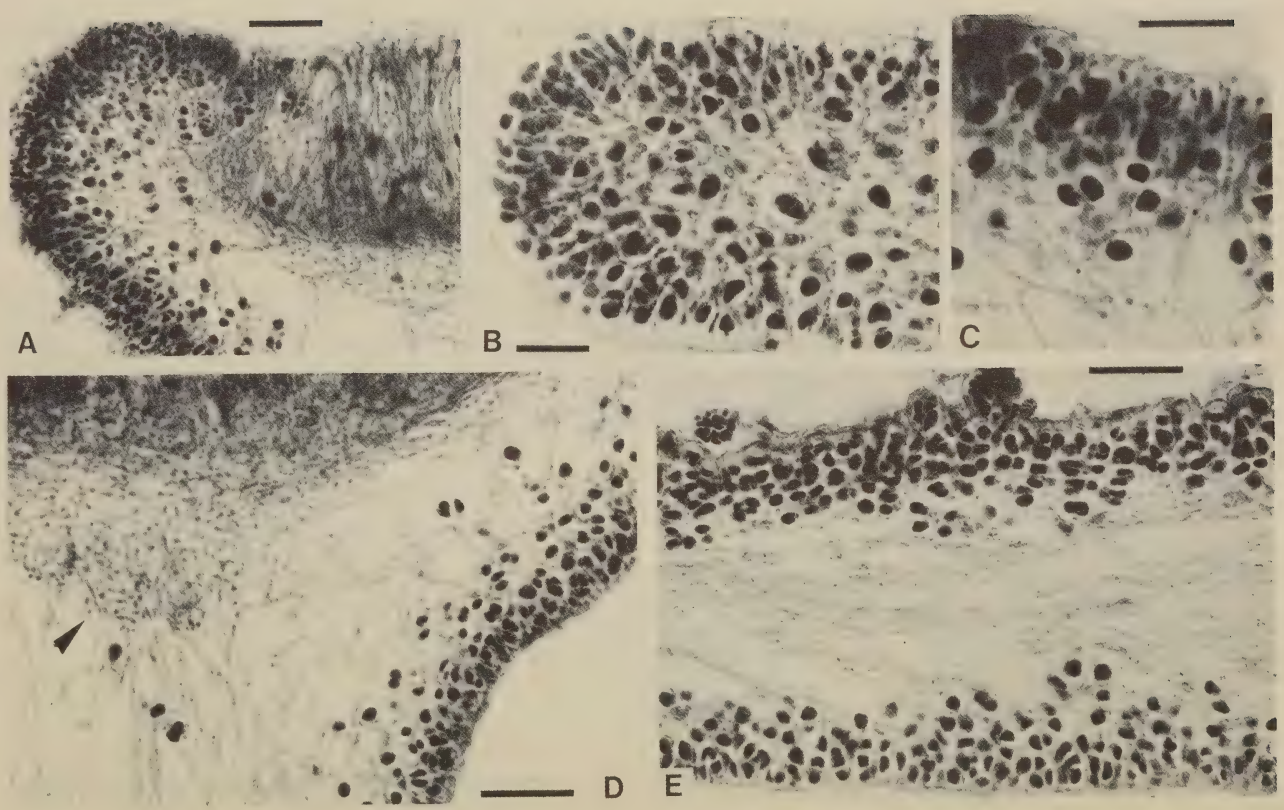
Thyrea divergens Henssen sp. nov.
Figs. 1E-F, 3A-E

DIAGNOSIS. Thallus rosulatus, fruticulosus, nigricans, isidiosus, usque ad 10 mm latus, umbilico affixus. Lobi erecti, applanati, ramosi, 3-5 mm longi et 0.5-0.8 mm lati, apice divergenti, isidia globosa, usque ad 0.3 mm lata. Hyphae ordinatae longitudinaliter in centro thalli et perpendiculariter versus marginem, cortex deest, cellulae algarum ad zonam marginale restrictae. Alga verosimiliter ad ordinem Pleurocapsales pertinens, cellulae (4.5-)6-12 µm latae. Apothecia marginalia, adnata, usque ad 1 mm lata. Hymenium 70-100 µm altum, in iodo vinosum, hypothecium 25-35 µm altum, excipulum proprium 45-50 µm crassum, ad basi restrictum et in stipite elongatum. Asci cylindracei, 6-8-spori, 60-80 x 10-12 µm. Sporae eseptatae, incolores, ellipsoideae, 12-14 x 8 µm. Pycnidia marginalia, c. 0.15 mm lata, conidia fusiformia, 2.5-4 x 1 µm.

Typus: Kenya, Eastern Province, Distr. Marsabit, Lake Turkana, Koobi Fora, 3°55'N 36°12'E, on rocks, c. 1800m, 1983, Hindmarsh 58 (MB-holotypus; BM, EA-isotypi).

Thallus blackish, to 10 mm large, rosette-shaped, fruticose, isidiate, attached by central umbilicus. Lobes more or less erect, 3-5 mm long, 0.5-0.8 mm wide and c. 0.06-0.8 mm thick, flat-

Fig. 1. Habit photographs of Thyrea species. A-D, T. polyglossa (A, isotype-UPS, B, Henssen 28734c-MB, C, isotype-G, D, lectotype-H); A, tongue-shaped lobes; B, lobe bearing submarginally a young apothecium (arrow); C, isidia in part elongated into lobuli; D, thallus under side. E-F, T. divergens (holotype); E, thallus under side; F, lobes bearing marginal apothecia. Scale = 1mm.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tened, plane or furrowed on the under side, richly branched, the side branches divergent; isidia globular, to 0.3 mm wide. Thallus heteromerous, algal zone 20-50 µm high, central hyphae 1.5-2.5 µm thick, lying horizontally, anticlinally orientated towards margin and cells enlarged to 7 µm (Fig. 3E). Phycobiont probably a member of the Pleurocapsales, algal cells singly or in pairs, cells (4.5-)6-12 µm diam.

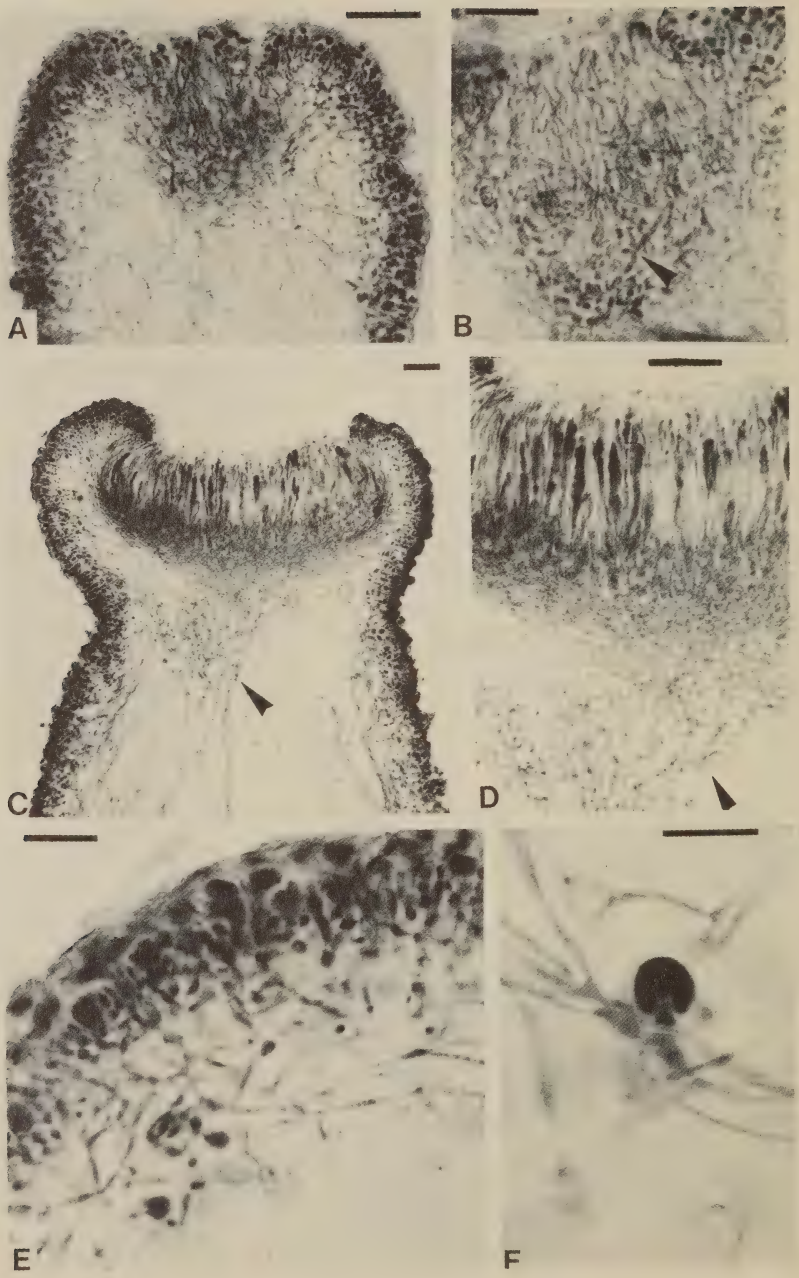
Apothecia marginal, to 1 mm diam., thalline margin c. 0.1 mm thick, disc brown. Hymenium 70-100 µm, hymenial gelatin in iodine becoming blue to wine-red, hypothecium 25-35 µm, excipulum 45-50 µm, composed of roundish cells, elongated into a stipe of loosely interwoven hyhae (Fig. 3C-D). Paraphyses 1.5-2 µm thick, the apical cells enlarged to 3.5 µm. Asci cylindrical, 60-80 x 10-12 µm, frequently containing fewer than 8 spores. Spores simple, colourless, ellipsoid, 12-14 x 7-8 µm. Pycnidia marginal, c. 0.15 mm broad, conidia short, fusiform, 2.5-4 x 1 µm, produced terminally by elongated conidiogenous cells.

Ecology and distribution. T. divergens grows on calcareous rock. It is known only from the type locality.

The epithet "divergens" refers to the divergent manner of growth of the side branches of the lobes.

Remarks. The thallus is blackish in surface view while on the under side the basal parts of the lobes adjacent to the substrate are pale from

Fig. 2. Anatomy of Thyrea polyglossa (microtome sections in LPCB; A-B, lectotype-H, C-D, Henssen 28374c-MB, E, isotype-UPS). A, l. s. of apothecium, branched paraphyses of varying length; B, l. s. of lobe tip in tangential section, hyphae in reticulum with vacuolated cells C, l. s. of thallus margin with anticlinaly arranged hyphae; D, l. s. of apothecium, part of hypothecium with adjacent loose hyphal web (arrow); E, l. s. of thallus with central hyphal strand and marginal zone of algal cells. Scale in A, D-E = 50 µm, in B-C = 20 µm.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decay (Fig. 1E). Only some of the thalli were fertile, bearing aggregated apothecia in the centre (Fig. 3F). The developmental morphology of the ascocarp has been followed from the initial stages. The young paraphyses and remains of ascogonia and trichogynes seen in Fig. 3A-B indicate that they develop in the manner normally found in the Lichinaceae via a hyphal web of generative tissue (cf. Henssen 1963, Henssen 1981). In mature apothecia the paraphyses are distinctly septate and only sparsely anastomotic; the tips are covered by a thick gelatinous layer (Fig. 3C-D).

In the anatomy of the thallus and apothecium T. divergens corresponds well to T. polyglossa but differs in a more distinctly developed excipulum proprium, which is a compact structure composed of roundish cells.

T. divergens is characterized by the deeply lobate, rosette-shaped thallus with erect, flat, richly branched lobes having divergent tips. From T. polyglossa it is easily distinguished by the branching pattern (cf. Figs. 1D and E), and fertile specimens also by the different iodine reaction. From other species of Thyrea it differs in the same way as T. polyglossa (see above).

Relationships of Thyrea polyglossa and Thyrea divergens to other species of the genus. The corresponding internal morphology of the thallus and apothecia indicates a close relationship between T. polyglossa and T. divergens. A heteromerous thallus with a distinct algal zone is found also

Fig. 3. Anatomy of Thyrea species (microtome sections in LPCB). A-E, T. divergens (holotype-MB); A-B, l. s. of apothecial primordia. Remains of trichogyne indicated by an arrow; C, l. s. of mature apothecium, stipe of loose hyphal web indicated by arrow; D, hymenium and stipe (arrow) at higher magnification. E, l. s. of thalline margin with anticlinally arranged hyphae. F, T. polyglossa (Henssen 28374c-MB); haustorium in algal cell. Scale in A-D = 50 µm, in E-F = 20 µm.

in T. rotundata and in the T. giradii-group. T. girardii (DR) Bagl. & Car. and related species differ, however, in having an orbicular thallus and laminal, immersed pycnoascocarps; the group is considered to be more closely related to T. plectospora, which has a similar developmental morphology of the apothecia. T. rotundata, on account of the characteristics mentioned above, is in our opinion intermediate between T. polyglossa/T. divergens and the T. giradii-group. A discussion of the delimitation of Thyrea from other genera of the Lichinaceae and an attempt at a subdivision of the genus into satisfactory sections will be provided in a forthcoming paper.

ACKNOWLEDGEMENTS

The study was supported by the Deutsche Forschungsgemeinschaft. I am greatly indebted to Dr.T.D.V. Scwinscow for sending me the new East African species to describe, and for comments on the manuscript. Mrs G. Traute is thanked for technical assistance.

ZUSAMMENFASSUNG

An Hand von fertilem Material aus Mexico können erstmals Angaben über die Apothecien und Pycnidien von Thyrea polyglossa (Nyl.) Zahlbr. gemacht werden. Die Flechte stimmt in Habitus und Anatomie weitgehend mit der hier neu beschriebenen Thyrea divergens Henssen von Ostafrika überein. Die beiden Arten zeichnen sich durch ein heteromeres Lager mit unterschiedlicher Hyphendifferenzierung im Innern und marginalem Teil des Thallus aus. Die Apothecien entwickeln sich über einen Hyphenknäuel aus generativem Gewebe, eine excipuloide, in einen Stiel sich verlängernde Struktur ist auf den basalen Teil des Fruchtkörpers beschränkt; sie besteht bei T. polyglossa aus einem lockeren Hphengeflecht, bei T. divergens aus dicht gedrängten rundlichen Zellen. Bei beiden Arten ist der umbilicate Thallus tief in Loben eingeschnitten. Er bildet bei T. polyglossa eine flache Rosette aus Loben mit wenig Seitenästen, bei T. divergens dagegen ein strauchig aufrechtes Lager aus reich verzweigten Loben, deren Enden divergieren (Name!). Beide Arten sind isidiös;

die Isidien sind bei T. divergens klein und kugelig, bei T. polyglossa größer, langestreckt und können zu Lobuli auswachsen. Asci und Sporen wurden bei beiden Arten nur in schlecht entwikkeltem Zustand beobachtet, die Hymenialgallerte färbt sich bei T. polyglossa blau, bei T. divergens über blau weinrot. Die Pycnoconidien sind bei beiden Arten kurz spindelig. Die Arten sind Kalklbewohner, T. polyglossa wurde bisher auf Cuba, Mona Island bei Puerto Rico und in Mexiko gefunden, T. divergens ist nur von der Typuslokalität in Kenya bekannt. Die beiden Arten sind nahe miteinander verwandt; die nächsten Beziehungen scheinen zu T. rotundata Büdel et al. zu bestehen, die eine Zwischenstellung zur T. giradii-Gruppe einnimmt.

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MYCOTAXON

Vol. XXV, No. 2, pp. 505-518 April-June 1986

THE GENUS ARTHRODERMA AND ITS LATER SYNONYM NANNIZZIA

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SUMMARY

Based upon a careful evaluation of the morphological characteristics used to define the genera Arthroderma and Nannizzia, it is concluded that these two taxa are congeneric. Owing to priority, Nannizzia is a later synonym of Arthroderma. The following new combinations are proposed: A. borellii, A. cajetani, A. cookiellum, A. corniculatum, A. fulvum, A. grubyi, A. gypseum, A. incurvatum, A. obtusum, A. otae, A. persicolor, and A. racemosum. Neotypes have been designated for A. cajetani and A. grubyi.

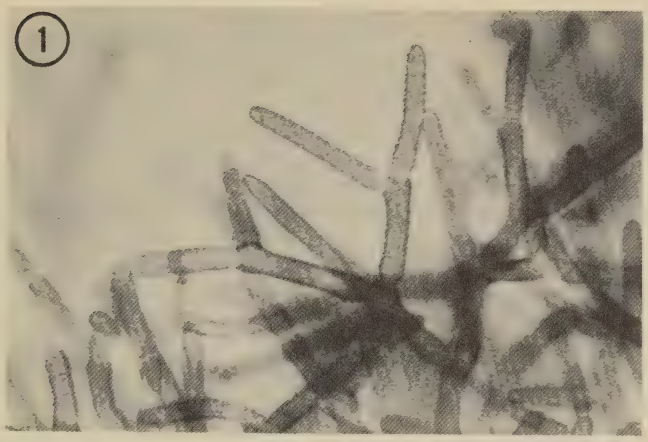
INTRODUCTION

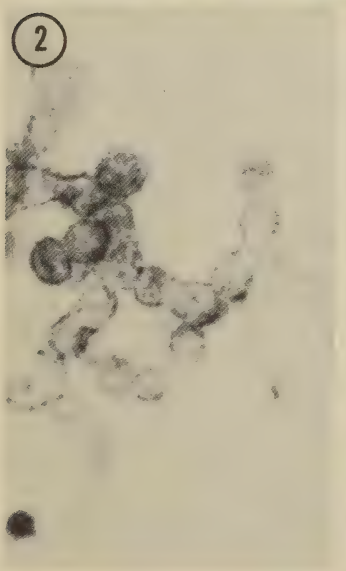
In 1854, Currey (10) provisionally proposed the genus Arthroderma for a fungus occurring on dead leaves and sticks. Berkeley (9) validated the genus Arthroderma in 1860 and named Currey's fungus A. curreyi. Saccardo misinterpreted the ascocarps of A. curreyi as sporodochia and incorrectly considered the genera Illosporium and Arthroderma congeneric (33). Members of the genus Arthroderma produce small gymnothecia having hyaline, branched, septate peridial hyphae consisting of either

symmetrically or asymmetrically dumbbell-shaped densely asperulate cells. The asci are globose to subglobose, evanescent and eight-spored. The 1-celled ascospores are smooth, oblate and yellow in mass (28).

The genus Nannizzia was established in 1961 by Stockdale to accommodate N. incurvata, the teleomorph of Microsporum gypseum (34). Species of Nannizzia are characterized by producing globose gymnothecia having a peridium (Figs. 1-2) consisting of a network of hyaline, septate, verticillately branched hyphae and densely asperulate outer peridial cells that are moderately thick-walled and more or less symmetrically constricted, as well as three kinds of peridial appendages. The appendages consist of: 1) elongate, tapering, straight or loosely coiled hyphae, 2) tightly coiled hyphae (spirals), and 3) macroconidia. The hyaline, evanescent asci are globose to ovate, with eight oblate ascospores; the ascospores are yellow in mass. Even though Stockdale felt that N. incurvata most closely resembled A. curreyi, she considered the differences in the appearance of the peridium to be of sufficient significance to warrant the establishment of the new genus Nannizzia. The distinguishing features used to separate these two genera included: 1) the branching of the peridial hyphae in A. curreyi is consistently dichotomous rather than verticillate as in N. incurvata, 2) the cells of the outer peridium of A. curreyi have small protuberances which are absent in N. incurvata, 3) the long, straight, or loosely coiled terminal extensions of the peridial hyphae characteristic of the Nannizzia spp. are absent in A. curreyi, and 4) the spiral appendages in A. curreyi are predominately lateral (34).

Since the establishment of the genus Nannizzia (34), several new species have been described which has resulted in a broadening of the generic concept of this taxon (1,13,16,35). For example, the branching of the peridial hyphae in N. obtusa is mostly dichotomous and only occasionally verticillate (13). In N. grubyi it is dichotomous and uncinate, but never verticillate (16). As a result of these findings and unpublished observations, Stockdale expressed doubt in maintaining these fungi in two separate genera. Nevertheless, she retained them as distinct genera because of the presence of protuberances on the peridial hyphal cell walls of Arthroderma, structures which are absent in species of Nannizzia (35).





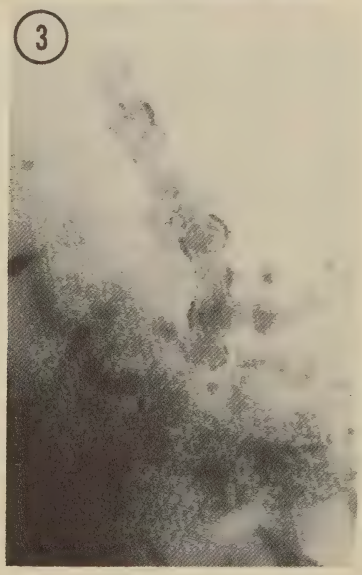


Fig. 1. Nannizzia cajetani. Slightly constricted peridial hyphal cells, X 600. Fig. 2. N. otae. Symmetrically constricted peridial hyphal cells, X 1440. Fig. 3. Arthroderma simii. Peridial hyphal cells showing roughened cell walls in the constricted area, X 1440. Figs. 1 and 2 reproduced with permission from Sabouraudia 1:173-177, 1961 and Trans. Br. Mycol. Soc. 81:645-650, 1983, respectively.

In 1979, Takashio (38) stated that "the only distinguishing features of these genera is the morphology of the peridial cells. The two genera might be unified in the genus Arthroderma." McGinnis (25) also suggested that Arthroderma and Nannizzia could be considered congeneric because he felt that the differences in the degree of constriction of the cells composing the peridial hyphae were not siginificant at the generic level. Because the identification of species classified in these two genera relies so heavily upon their anamorphs rather than their teleomorphs, this also tends to support the union of Arthroderma and Nannizzia. The situation involving Arthroderma and Nannizzia parallels that of Ajellomyces and its later synonym Emmonsiella (26).

CHARACTERISTICS OF ARTHRODERMA AND NANNIZZIA

In 1967, Stockdale described N. persicolor as the teleomorph of Trichophyton persicolor (36). Unlike the other Nannizzia species previously described, the peridial hyphal cells of N. persicolor were dumbbell-shaped with only one slight constriction in the middle. The peridial appendages consisted of numerous spirals that were often branched. Long, straight hyphae and macroconidia characteristic of Nannizzia spp. were not observed. Stockdale now considers the separation of these genera on the basis of the peridial hyphae as weak, but still believes that they should be maintained as separate genera because they have different conidial states, e.g. Nannizzia has a Microsporum anamorph and Arthroderma either a Trichophyton or Chrysosporium anamorph. Stockdale might have considered Nannizzia synonymous with Arthroderma, if she had not observed "slightly verruculose walls" on the macroconidia of T. persicolor, thereby, rendering it by definition a species of Microsporum (2). It is important to note that Article 59 of the Code states that an anamorph cannot be used to define a teleomorph.

Additional Nannizzia spp. deviating from the original concept of the genus include N. otae (17,24) and N. borellii (27), both of which have dichotomous rather than verticillate branching peridial hyphae, and N. cookiella which has spiral appendages (14). Nannizzia otae forms dumbbell-shaped peridial hyphal cells which are sharply constricted in the middle (Fig. 2), a key characteristic of the

genus Arthroderma. In addition, it produces the three types of appendages that are characteristic of the genus Nannizzia (24).

Nannizzia-like characteristics found in species of Arthroderma include: 1) some rough rather than entirely smooth cell walls in the intervening constricted portions of the outer peridial hyphal cells as in A. simii (Fig. 3), A. benhamiae, and A. vanbreuseghemii (37), 2) symmetrically constricted dumbbell-shaped cells of the peridial hyphae lacking protuberances as in A. lenticularum (31) and A. vanbreuseghemii (37), 3) formation of elongate tapered hyphae as peridial appendages in A. benhamiae (3) and A. ciferrii (41), and 4) macroconidia occurring as peridial appendages (albeit infrequently) like those produced by A. uncinatum, A. simii, A. flavescens, and A. gertleri (28).

Current concepts for the classification of the ascomycetes emphasize the structure of the ascus and ontogeny of the centrum (8,15). However, generic descriptions of taxa within the Gymnoascaceae have been based primarily on the absence or presence of peridial hyphae and their appendages, peridial morphology, ascospore morphology and color (4,7). Von Arx (5,6) considered the peridial hyphae and their appendages of limited taxonomic significance because they may be present or absent depending upon growth media, humidity, light and age. For example, Dawson & Gentles (13) observed differences in the peridium of A. uncinatum which were dependent on the medium employed to induce the perfect state. In his discussion of the Gymnoascaceae, von Arx (5,6) considered the size and shape of the ascospores and the type of ascocarp initials as useful characters for the deliniation of the various genera. These characters, in addition to the absence or presence of the peridial hyphae and appendages, their morphology, the size and color of the ascomata, and appearance of the ascospore wall are important criteria for distinguishing the genera of the Gymnoascaceae (5). Fennell (15) considered ascocarp initials, origin of the peridial hyphae and asci, appearance of the ascospores and the anamorph to be of generic significance in her classification of the Plectomycetes.

The principal taxonomic criteria suggested by von Arx (5,6), Fennell (15), Padhye and Carmichael (28), Stockdale

(34), and others are summarized in Table 1 as a means to compare and contrast the genera Arthroderma and Nannizzia. Ascocarp initiation, the development of the ascocarp and its centrum, the ontogeny of the asci, and the appearance of the asci and ascospores are essentially the same in both genera (1,3,18,22,23,34,40,43). Ascospores, which had been described as lenticular in some Arthroderma and Nannizzia species, have been redescribed as oblate sphaeroids by Padhye & Carmichael (29).

The peridial hyphae in most species of Arthroderma are typically uncinately branched. The branching is sometimes dichotomous but never verticillate. The branching of the peridial hyphae in species of Nannizzia is commonly verticillate, sometimes dichotomous, and more rarely uncinate. Hence, there is an overlap with no sharp demarcation between these two genera. With regard to peridial appendages, lateral or terminal spirals may be found in both genera. Other appendages, such as the long straight tapered hyphae and macroconidia, are more commonly found in species of Nannizzia, but they may also be present in some species of Arthroderma. In Arthroderma, the outer cells of the peridial hyphae are always deeply constricted, and usually smooth in the mid-region, giving an appearance of a dumbbell. These cells may be symmetrically or asymmetrically dumbbell-shaped.

The Nannizzia spp. have uniformly roughened outer peridial cell walls. The degree of roughness varies with the species from minutely echinulate to densely verruculose or asperulate. The outer peridial cells are also constricted. However, depending upon the species, there may be 1-3 constrictions per cell. They may vary from minimally constricted as in N. cajetani (Fig. 1) to deeply constricted and dumbbell-shaped as in N. otae (Fig. 2), the latter thereby resembling Arthroderma.

CONCLUSIONS

In our opinion, the reasons for creating the genus Nannizzia are no longer applicable. The characteristics of the teleomorphic species, reported since the original description of this genus, are similar to those of the genus Arthroderma (Table 1). The only distinctions

Table 1. Summary of the principle taxonomic characteristics of Arthroderma and Nannizzia

	Arthroderma	Nannizzia
Ascocarp initiation	Club-shaped, septate antheridium surrounded by a coiled ascogonium; croziers develop from the septate ascogonial coil. Gymnothecial initial becomes surrounded by hyphae growing from the antheridium or vicinity.	Club-shaped, septate antheridium surrounded by a coiled ascogonium; croziers develop from the septate ascogonial coil. Gymnothecial initial becomes surrounded by hyphae growing from the antheridium or vicinity.
Ascocarps	Globose, whitish to pale yellow to buff, 100-970 µm excluding appendages.	Globose, pale yellow to yellow, buff to tan, 150-1250 µm excluding appendages.
Peridial hyphae	Hyaline, septate, pale yellow or pale buff, branching typically uncinate, sometimes dichotomous.	Hyaline, septate, pale yellow or pale buff, branching typically verticillate, sometimes dichotomous, rarely uncinate.
Outer cells of peridial hyphae	Dumbbell-shaped, symmetrical or asymmetrical, densely asperulate, echinulate or verruculose.	Slightly constricted to dumbbell-shaped, symmetrical, densely asperulate, echinulate or verruculose.
Peridial appendages	1. Spirals (terminal or lateral). 2. Elongate straight hyphae (usually rare). 3. Rarely, macroconidia or microconidia.	1. Spirals (terminal or lateral). 2. Elongate straight hyphae. 3. Macroconidia.
Asci	Globose to subglobose, evanescent, 8-ascospores, 3.9 - 8.3 x 3.5 - 7.5 µm.	Globose to ovate, evanescent, 8-ascospores, 4 - 7 x 5 - 7 µm.
Ascospores	Hyaline, smooth, lenticular, oval, oblate, yellow in mass, 1.5 - 3.5 x 1.4 - 3.5 µm.	Hyaline, smooth, lenticular, oval, ovate, oblate, yellow in mass, 1.5 - 6 x 1.6 - 4 µm.
Conidia	Holothallic macroconidia.	Holothallic macroconidia.
Anamorphs	*Chrysosporium* spp., *Trichophyton* spp.	*Microsporum* spp.

between these genera lies in their anamorphs, which are primarily differentiated from each other by the appearance of the macroconidial cell walls, i.e. roughened in the Microsporum spp. and smooth in the Trichophyton spp. However, smooth-walled mutants have been reported in M. gypseum (42,44), and M. persicolor was once considered a Trichophyton sp. because its macroconidial cell walls were originally thought to be smooth. The genera Trichophyton and Microsporum are closely related antigenically and biochemically (21). This relationship has been supported most recently by fatty acid data (20), zymogram patterns (19), DNA base ratio studies (11), and DNA hybridization analysis (12).

It is clear that the various species classified in the genera Arthroderma and Nannizzia represent a continuum. The differences observed in these fungi no longer merit maintaining them in two separate genera. We believe that Arthroderma and Nannizzia are congeneric and that the species currently classified in the genus Nannizzia must be transferred to Arthroderma.

There is some controversy regarding the relationship of these fungi to the genus Rollandina, which is based upon the type species R. capitata (30). We have excluded this genus because the ascospores of R. capitata have an equatorial band, a characteristic which is absent in all of the accepted species of Arthroderma.

TAXONOMIC PART

Arthroderma Currey ex Berkeley emend. Weitzman, McGinnis, Padhye et Ajello. Type Species: A. curreyi Berkeley. Outlines of British Fungology, p. 357, 1860. = Nannizzia Stockdale, Sabouraudia 1:45, 1961.

Gymnothecia globose, whitish to pale yellow or buff; peridium consisting of a densely packed network of interwoven hyphae; peridial hyphae hyaline, pale yellow or buff, septate, usually uncinately, verticillately or dichotomously branched; outer peridial hyphal cell walls echinulate, densely asperulate or verruculose, with 1-3 slight to moderate constrictions, or deeply constricted in the middle, symmetrically or asymmetrically

dumbbell-shaped; peridial appendages consist of tightly to loosely coiled spiral hyphae which may be terminal or lateral, some species producing additional terminal appendages consisting of elongate slender tapered hyphae, or macroconidia; gymnothecial initials composed of a clavate antheridium surrounded by a coiled ascogonium; asci globose, subglobose, or oval, evanescent, 8-spored, 3.9-8 x 3.5-7.5 µm; ascospores oval, lenticular, oblate, smooth, hyaline, yellow in mass, 1.5-6 x 1.4-4 µm; homothallic or heterothallic; Chrysosporium, Microsporum, or Trichophyton anamorphs.

1. Arthroderma borellii (Moraes, Padhye et Ajello) Padhye, Weitzman, McGinnis et Ajello, comb. nov.
   basionym: Nannizzia borellii Moraes, Padhye et Ajello, Mycologia 67:1112, 1975.

2. Arthroderma cajetani (Ajello) Ajello, Weitzman, McGinnis et Padhye, comb. nov.
   basionym: Nannizzia cajetani (as "cajetana") Ajello, Sabouraudia 1:175, 1961.

3. Arthroderma cookiellum (de Clercq) Weitzman, McGinnis, Padhye et Ajello, comb nov.
   basionym: Nannizzia cookiella de Clercq, Mycotaxon 18:24, 1983.

4. Arthroderma corniculatum (Takashio et de Vroey) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
   basionym: Nannizzia corniculata Takashio et de Vroey, Mycotaxon 14:384, 1982.

5. Arthroderma fulvum (Stockdale) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
   basionym: Nannizzia fulva Stockdale, Sabouraudia 3:120, 1963.
   syn: N. gypsea (Nannizzi) Stockdale var. fulva (Stockdale) Apinis, Mycol. Paper 96:33, 1964.

6. Arthroderma grubyi (Georg, Ajello, Friedman et Brinkman) Ajello, Weitzman, McGinnis et Padhye, comb. nov.
   basionym: Nannizzia grubyi (as "grubyia") Georg, Ajello, Friedman et Brinkman, Sabouraudia 1:194, 1962.

7. Arthroderma gypseum (Nannizzi) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
basionym: Gymnoascus gypseus Nannizzi, Atti. Accad. Fisioscr. Siena Med.-fis. 2:93, 1927.
syn: Nannizzia gypsea (Nannizzi) Stockdale, Sabouraudia 3:119, 1963. N. gypsea (Nannizzi) Stockdale var. gypsea, Mycol. Paper 96:32, 1964.

8. Arthroderma incurvatum (Stockdale) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
basionym: Nannizzia incurvata Stockdale, Sabouraudia 1:46, 1961.

9. Arthroderma obtusum (Dawson et Gentles) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
basionym: Nannizzia obtusa Dawson et Gentles, Sabouraudia 1:56, 1961.

10. Arthroderma otae (Hasegawa et Usui) McGinnis, Weitzman, Padhye et Ajello, comb. nov.
basionym: Nannizzia otae Hasegawa et Usui, Jpn. J. Med. Mycol. 16:151, 1975.

11. Arthroderma persicolor (Stockdale) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
basionym: Nannizzia persicolor Stockdale, Sabouraudia 5:357, 1967.
syn: Nannizzia quinckeani Balabanov et Schick, Dermatol. Venerol. 9:35-36, 1970.

12. Arthroderma racemosum (Rush-Munro, Smith et Borelli) Weitzman, McGinnis, Padhye et Ajello, comb. nov.
basionym: Nannizzia racemosa Rush-Munro, Smith et Borelli, Mycologia 62:858, 1970.

NEOTYPIFICATION OF A. CAJETANI AND A. GRUBYI

The holotypes for N. cajetani (as "cajetana") (1b) and N. grubyi (as "grubyia") which consisted of permanently preserved fertile gymnothecia mounted on microscope slides, have been lost. We have prepared neotypes in the form of dried colonies for A. cajetani (CDC B-4218) and A. grubyi (CDC B-4219), which have been deposited in the Division of Mycotic Diseases, Centers for Disease Control, Atlanta, Georgia.

The neotypes are identical to the original descriptions for these two taxa and were prepared from isolates derived from the cultures originally used to prepare the holotypes for N. cajetani (CDC B-434 and CDC B-435) and N. grubyi (CDC X-322 and CDC X-321).

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Donald P. Rogers for reviewing our manuscript.

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MYCOTAXON

Vol. XXV, No. 2, pp. 519-522 April-June 1986

A NOTE ON THE TYPIFICATION OF *GUIGNARDIA*

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SUMMARY

Typification of *Guignardia* Viala et Ravaz is discussed. The prevailing concept of typification by *G. bidwellii* (Ellis) Viala & Ravaz is shown to be incorrect. *Guignardia* was introduced as a nomen novum for *Laestadia* Auersw. (non *Laestadia* Lessing) and must be based on the same type, *Laestadia alnea* (Fr.:Fr.) Auersw., which is not congeneric with *G. bidwellii*. If current taxonomic arrangements are followed, then *Guignardia* becomes a later synonym of *Plagiostoma* Fuckel. The segregation of *Guignardia* (auct.) species having *Phyllosticta* anamorphs from species (mostly referable to *Discosphaerina* v. Höhnel) with anamorphs in other genera allows *Discochora* v. Höhnel to be adopted for the teleomorphs of *Phyllosticta*.

* * *

Guignardia was introduced by Viala and Ravaz (1892) as a replacement name for *Laestadia* Auersw. 1869, a later homonym of *Laestadia* Kunth ex Lessing 1832 (Compositae). Viala and Ravaz did not provide, or refer to, a description or diagnosis for their new generic name, consequently *Guignardia* must be considered a nomen novum based on the same type as *Laestadia* Auersw., which it was proposed to replace (ICBN, Arts. 32.1.c, 72.1). Viala and Ravaz applied the name only to *Sphaeria bidwellii* Ellis, not realizing that the type species of *Laestadia* Auersw., *L. alnea* (Fr.: Fr.) Auersw., differed generically from *G. bidwellii*. The differences were

noted by v. Höhnel (1918b) and he erected a new genus, *Gnomonina*, for *L. alnea*, and concluded that *Guignardia* auct. (based on *G. bidwellii*) was the same as *Phyllachorella* Sydow 1914. Sydow and Sydow (1919) saw that *Guignardia* was a replacement name for *Laestadia* and retained *L. alnea* as the type making *Gnomonina* a synonym of *Guignardia*. Müller and von Arx (1962) referred both *Laestadia* and *Gnomonina* to *Plagiostoma* Fuckel 1869. Consequently, *Guignardia* Viala et Ravaz, based on the same type as *Laestadia* and *Gnomonina*, becomes a synonym of the earlier name *Plagiostoma* in current taxonomic arrangements (Barr, 1978; Monod, 1983).

In recent years, the majority of authors have followed von Arx and Müller (1954) in maintaining the generic name *Guignardia* and citing *G. bidwellii* as the type species. According to the International Code for Botanical Nomenclature, the retention of a name in a sense that excludes the type can only be effected by conservation (ICBN, Art. 48). A proposal to conserve *Guignardia* Viala et Ravaz versus *Carlia* Bon. 1864 (non *Carlia* Rabenh. 1857) concluded with the recommendation from the nomenclatural committee that *Guignardia* be accepted as the valid name for the genus previously called *Laestadia* Auersw., and therefore in no need of conservation against *Carlia* Bon., which has no valid existence (Wakefield, 1939). This proposal erroneously cited *G. bidwellii* as the type species of *Guignardia*. There has never been a proposal to conserve *Guignardia* auct., typified by *G. bidwellii*, against *Guignardia* Viala et Ravaz, typified by *L. alnea*.

Von Höhnel (1918b) referred *G. bidwellii* to *Phyllachorella* Sydow 1914. Most recent authors consider *Phyllachorella micheliae* Sydow, the type species, to be generically distinct from *G. bidwellii*, differing in the structure of the ascomata (von Arx and Müller, 1954; Barr, 1972). *Discosphaerina* v. Höhnel 1917 was listed as the earliest synonym for *Guignardia* auct. by von Arx and Müller (1954), and this synonymy was accepted by van der Aa (1973). Petrak (1958) concluded that *G. bidwellii* and related species could be accommodated in *Botryosphaeria* Ces. & de Not. 1863, and he retained *Discosphaerina* for a group of aparaphysate species of *Guignardia* auct. Barr (1970, 1972) followed Petrak in transferring species of *Guignardia* auct. with

Phyllosticta anamorphs to *Botryosphaeria*, and referring species with depressed ascomata and numerous oblong asci to *Discosphaerina*. Van der Aa (1973) maintained the distinction between *Botryosphaeria* and *Guignardia* auct., transferring species classified as *Botryosphaeria* by von Arx and Müller with *Phyllosticta* anamorphs to *Guignardia* auct.

Punithalingam (1974) advocated that the genus *Guignardia* auct. be maintained, but only for holomorphs with *Phyllosticta* anamorphs, "as typified by *G. bidwellii*". Punithalingam's segregation of the species with *Phyllosticta* anamorphs is justified by characteristics of the teleomorphs. *Botryosphaeria* can be distinguished from this circumscription of *Guignardia* auct. by usually larger ascomata and ascospores, and an extended and frequently multilocular stroma. Van der Aa (1973) details differences between the two genera in growth characters in culture. Anamorphs for *Botryosphaeria* have been reported in the genera *Botryodiplodia*, *Lasiodiplodia*, *Dothiorella* and *Diplodia*. *Discosphaerina* differs in having depressed ascomata, a less developed stroma, more numerous asci developing almost simultaneously, and earlier disintegration of the locule tissues (Petrak, 1958, Barr, 1972). Anamorphs reported for *Discosphaerina* are in the genera *Kabatia*, *Colletotrichella*, *Placosphaeria* and *Selenophoma*. *Discochora* v. Höhnel (1918a) is the earliest available name for holomorphs with *Phyllosticta* anamorphs (Barr, 1972). Von Arx and Müller (1954) listed *Discochora* as a synonym of *Botryosphaeria*. However, the type species, *D. ilicis* v. Höhnel, was one of the species with *Phyllosticta* anamorphs classified as *Botryosphaeria* by von Arx and Müller and transferred to *Guignardia* auct. by van der Aa (1973).

In his monograph of the genus *Phyllosticta*, van der Aa cites teleomorphs for 12 species. All of these teleomorph based names, currently assigned to *Guignardia*, should be reassigned to *Discochora*, along with several names in *Guignardia* published subsequently for species with *Phyllosticta* anamorphs. The name *Discochora ilicis* (basionym: *Sphaeria ilicis* Schleich. in Ellis, N. Am. Fungi no. 196. 1879) is predated for the same fungus by *Sphaeria philoprina* Berk. & Curt. The correct name for the type species is, therefore, *Discochora philoprina* (Berk. & Curt. in Berk.) comb.

nov. (basionym: *Sphaeria philoprina* Berk. & Curt. in Berk., Grevillea 32:154. 1876).

ACKNOWLEDGEMENT

The author thanks Dr. M.E. Barr for her helpful discussions on this topic.

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MYCOTAXON

Vol. XXV, No. 2, pp. 523-526 April-June 1986

VALSEUTYPELLA MULTICOLLIS SP. NOV.

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SUMMARY

Valseutypella multicollis is described as new, based on specimens collected on *Quercus ilex* ssp. *rotundifolia*. It is characterized by stromata with 10-30 perithecia and eight-spored asci.

The genus *Valseutypella* (Diaporthales) was created by v. Höhnel (1918), who designated *Diatrype tristicha* de Not. as the type species. The genus remains monotypic (Barr, 1978; Hawksworth et al., 1983). The most important characteristics of this genus are its stroma, a receptacle composed of dark pseudoparenchymatous, sclerotial cells and upright perithecia with separately erumpent beaks. The asci usually contain four ascospores.

Valseutypella tristicha is known from Europe and North America on stems of *Rosa* spp. Hubbes (1960) provided details of its morphology and determined several physiological parameters. The species appears to be host specific. Hubbes obtained only slight growth on sterilized twigs of *Salix caprea* and *Populus alba*, whereas on twigs of *Rosa* sp. pycnidia were produced in three weeks and perithecia in six weeks. The stroma of *V. tristicha* is usually about 1 cm diam and contains 10-35 perithecia. Perithecial beaks are usually erumpent for a short distance only beyond the

stromatic surface, although in humid culture conditions they extend farther. The asci are normally four spored but occasional one-, two-, or three-spored asci may occur (Barr, 1978). V. Hühnel (1918) said "4-8 sporig" in his delimitation of the genus. Both asci and ascospores vary in size: asci 34-70 x 6.5-10.5 µm, ascospores (8-)11-15(-26) x (2.5-)3-4(-5) µm (Saccardo, 1882; Berlese, 1902; Hubbes, 1960; Barr, 1978). The number of ascospores per ascus would account for the extremes in size.

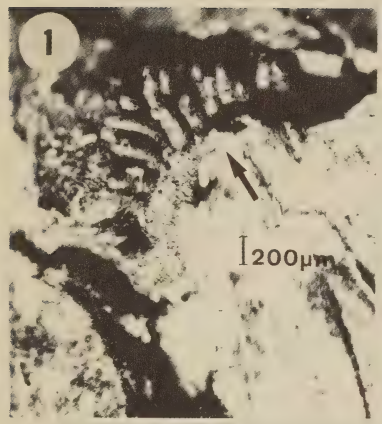
A species that forms similar but larger stromata, with long erumpent beaks and octosporous asci, was collected on *Quercus ilex* ssp. *rotundifolia* in Spain.

Valseutypella multicollis Checa, Moreno & Barr, sp. nov.

Stroma semiimmersum, circulare subglobosumve, nigrum, cuius diameter est 1.5-2.5 mm. Perithecia numero variant inter 10 et 30, colore subviridi, erecta, ostiolata; quorum venter ellipticus est et longus 430-480 µm cuius diameter est 240-340 µm; collum autem est cylindricum, angustius in apicem, emergens, rectum, 530-620 µm longum et cuius diameter est 100-150 µm, vergens super stroma. Stroma pseudoparenchymaticum, extrinsecus constitutum cellulis castaneo colore et pariete crasso, in cartilagineum tegumentum dispositis, quod est cassum 20-50 µm; intrinsecus autem fibrosum, constitutum hyphis connexis flavescente colore. Peridium ventris perithecii epidermoideae structurae, idemque colli structurae prosenchymaticae, extrinsecus tectum cellulis scleroticis castaneo colore. Asci 8 sporis praediti, cylindrico-claviformes, unitunicati, quorum apparatus apicalis est haud amyloideus, chitinoideus, 50-70 µm longus, 8-10 µm latus. Sporae biseriatele, allantoideae, glabrae, hyalinae, 14-18(-21) µm longae, 4-5 µm latae. Paraphyses absunt.

Habitat: Species lignicola fructificans in ramis mortuis *Quercus ilicis* subspeciei *rotundifoliae*, cuius corticem aufert, inter La Granja et Riofrio (Segovia, Hispania), leg. P. Yebes et J. Checa (10.VI.84), in herbarium J. Checa et G. Moreno 3854 (Holotypus). Isotypus Massachusetts Universitas (MASS).

Figs. 1-8. *Valseutypella multicollis*. 1. Macroscopic aspect of a stroma. 2. Microscopic detail of stroma and perithecium. 3. Detail of apex of beak. 4. Detail of texture of peridium. 5. Detail of texture of beak. 6. Ascus and ascospores. 7. Immature ascus. 8. Ascospores.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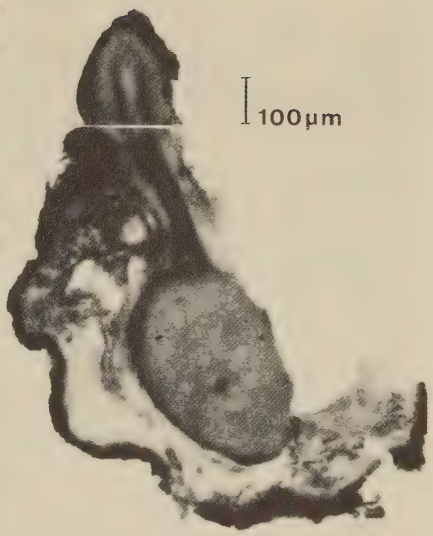
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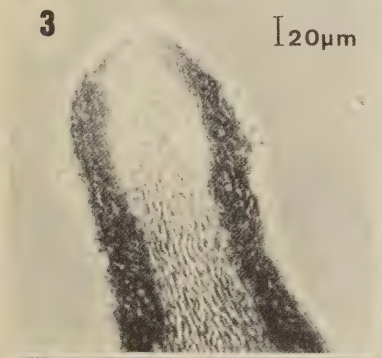
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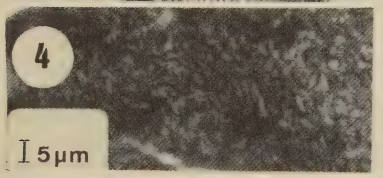
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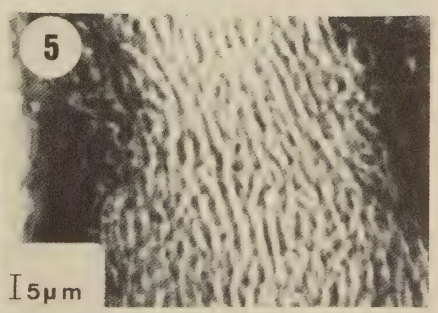
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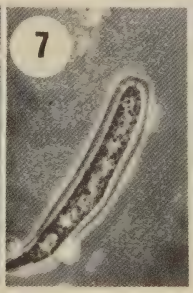
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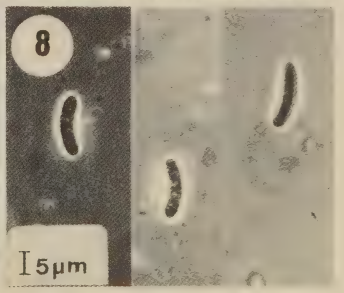
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Stroma semiimmersed, circular to subglobose, black; 1.5-2.5 mm diam. Perithecia variable in number, 10-30, greenish, upright, ostiolate; venters elliptic, 430-480 x 240-340 µm; beaks cylindrical, tapering near the apex, emergent straight, 530-620 x 100-150 µm, erumpent beyond stroma surface. Stromatic tissues pseudoparenchymatous, externally composed of brown, thick-walled cells which form a cartilaginous cover 20-50 µm in thickness; internally fibrous, composed of variegated hyphae, yellowish. Peridium of venter of perithecium textura epidermoidea and peridium of beak prosenchymatous, covered externally by brown sclerotial cells. Asci eight spored, cylindric-claviform, 50-70 x 8-10 µm, unitunicate, apical apparatus nonamyloid, chitinoid. Ascospores biseriate, allantoid, smooth, hyaline, 14-18(-21) x 4-5 µm. Paraphyses not observed.

Habitat: On dead branches of *Quercus ilex* ssp. *rotundifolia*, from La Granja to Riofrio (Segovia, Spain), 30T VL0526, leg. P. Yebes and J. Checa (10.VI.84); holotype in private herbarium of J. Checa and G. Moreno 3854, isotype in Herbarium University of Massachusetts (MASS).

Observations.--This species has not yet been cultured, so that no information on anamorphic state is available. The morphological characters of *V. multicollis* that separate it from *V. tristicha* are somewhat larger stromata containing numerous perithecia, perithecial beaks elongate beyond the surface of stroma, and longer ascospores. Assuming that *V. tristicha* is indeed host specific, the occurrence of *V. multicollis* on *Quercus* provides another valid character.

We thank Dr. C. T. Rogerson, The New York Botanical Garden, for reviewing the manuscript.

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MYCOTAXON

Vol. XXV, No. 2, pp. 527-538 April-June 1986

ILLINOIS FUNGI XII. FUNGI AND MYXOMYCETES FROM WOOD AND LEAVES SUBMERGED IN SOUTHERN ILLINOIS SWAMPS

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SUMMARY

One hundred and thirty-four fungal and 13 Myxomycete species were recorded on submerged, decayed plant substrates and balsa wood baits from two cypress-tupelo swamps and a hardwood swamp and its adjoining lake in southern Illinois. The mycota consists predominantly of dematiaceous and aeroaquatic Hyphomycetes and a variety of Ascomycetes. These swamps and lake contain numerous rare and indigenous fungal species and serve as the type locality for two genera and nine species.

INTRODUCTION

A number of fungi have been reported from submerged plant debris in freshwater swamps (Crane, 1971, 1972a,b; Shearer *et al.*, 1976; Shearer and Crane, 1978a,b, 1980a,b, 1985; Crane and Shoknecht, 1978, 1982; Schoknecht and Crane, 1978, 1983). There are, however, no reports of efforts made to systematically collect and identify fungi on decomposing submerged plant substrata in freshwater swamps. In this study, submerged plant substrata and balsa wood baits were collected monthly for 12 months from two cypress-tupelo swamps and a hardwood swamp and its adjoining lake. Fungi sporulating on substrata were identified and isolated when possible.

METHODS

Study Sites

Deer Pond (Elvira Cypress Swamp) and Heron Pond in Johnson County, and La Rue Swamp and adjoining Wolf Lake, in Union County, were the sites selected for study. In addition, Goose Pond (Johnson County) and Forman Swamp (Union County) were each sampled once. These sites are characterized by soil which is saturated with or covered by water for 12 or fewer months each year and by the presence of trees. Deer Pond and Heron Pond are cypress-tupelo swamps located in a bottomland region at the confluence of the Ohio and Mississippi rivers. Both swamps are flooded annually with floodwaters from the Cache River system. The dominant tree species in Deer Pond and Heron Pond are cypress (*Taxodium distichum* L.), water tupelo (*Nyssa aquatica* L.), and Drummond's red maple (*Acer rubrum* L. var. *drummondii* (Hook. & Arnott ex Nutt.) Sarge. The shrub community consists predominantly of buttonbush (*Cephalanthus occidentalis* L.), Virginia willow (*Itea virginica* L.), and swamp rose (*Rosa palustris* Marsh.). During the summer, the water surface is covered with mosquito fern (*Azolla mexicana* Presl.), duckweeds (*Spirodela polyrhiza* (L.) Schleid and *Lemna* spp.), and frogbit (*Limnobium spongia* (Bosc.) Steud). The submerged aquatic macrophyte, prickly coontail (*Ceratophyllum echinatum* Gray), occurs abundantly. Anderson and White (1970) and Dorge *et al.* (1984) have characterized the vegetation of Heron Pond in greater detail.

La Rue Swamp is located near the southwestern border of Illinois, about 15 km from the Mississippi River. This swamp is extensive and includes a variety of aquatic habitats. The swamp is fed by cool springs from the limestone cliffs which border one side of it. Extensive beaver activity is responsible, in part, for damming the swamp and reducing water flow. The flora of La Rue Swamp is quite diverse and has been treated in detail by Mohlenbrock and Voight (1965). There are only a few standing trees of cypress and water tupelo. The tree vegetation is dominated by swamp cottonwood (*Populus heterophylla* L.), pumpkin ash (*Fraxinus tomentosa* Michx.), water locust (*Gleditsia aquatica* Marsh.), and others. The shrub vegetation consists of buttonbush, Virginia willow, black willow (*Salix nigra* Marsh.), and swamp rose. A large number of aquatic macrophytes and sedges occur, and the water surface is covered with duckweeds and mosquito fern. Wolf Lake, which is adjacent to La Rue Swamp, is an old oxbow of the Mississippi River and has an extensive open water area. In this swamp and the others, organic plant material has accumulated to form a dense deposit of partially decomposed plant substrata on the swamp bottom. This deposit is anaerobic, and hydrogen sulfide and methane are released when it is disturbed.

Physical-Chemical Measurements

Temperature was measured with a thermometer, dissolved oxygen with a YSI oxygen meter, and pH with a Beckman field pH meter. Chemical water quality was analyzed by personnel at the Water Analysis Laboratory, Illinois Natural History Survey.

Collection Techniques

Strings of autoclaved balsa wood blocks (54 x 50 x 9 mm) were submerged for 1-month periods and returned to the laboratory where they were incubated at room temperature in moist chambers (petri dishes containing two pieces of filter paper moistened with distilled water and sealed with rubber dish seals). Submerged woody debris and leaves were also collected monthly and processed as above. Additional samples were collected and submerged in distilled water in glass petri dishes and incubated at 17 °C. Fungi were identified from fruiting structures found on incubated substrata. Single-spore isolates were obtained by plating spores on 1.8% distilled water agar containing 0.5 mg/l each of streptomycin sulfate and penicillin G (Sigma). Single spores were transferred to Emerson's yeast soluble starch agar (Difco) and isolates were deposited at the American Type Culture Collection (ATCC). Voucher specimens of all species found were deposited in the herbarium of the Illinois Natural History Survey (ILLS).

RESULTS

Ranges in physical-chemical water quality parameters are listed in Table 1. Temperature and dissolved oxygen fluctuated widely throughout the year (Fig. 1). High temperatures and low oxygen levels occurred in the summer and early fall, and oxygen levels remained low during leaf fall as temperatures decreased.

One hundred and thirty-four fungal and 13 Myxomycete species were found (Table 2). The greatest number of fungal species were Fungi Imperfecti and most of these were dematiaceous. The following species occurred regularly and in more than one swamp: *Didymium trachysporum*, *Oligonema flavidum*, *Cercophora* sp. I, *Chaetomium funicolum*, *Nais inornata*, *Talaromyces flavus*, *Zopfiella latipes*, *Allescheriella crocea*, *Beverwykella pulmonaria*, *Bispora betulina*, *Chloridium viride*, *Conioscypha varia*, *Dactylaria purpurella*, *Sporidesmium hyalospermum*, *Gonytrichum macrocladium*, *Neta patuxentica*, *Phaeoisaria clematidis*, *Thozetella tocklaiensis*, *Trichoderma harzianum*, and *Sporoschisma saccardoi*.

DISCUSSION

Wide ranges in all physical and chemical parameters except nitrite were encountered (Table 1). These ranges reflect the annual growth, maturation, and death of aquatic macrophytes, the autumnal input of leaf litter, alternating flooding and drying conditions, and seasonal changes in temperature. Extremes in some parameters, such as temperature, dissolved oxygen, ammonia concentrations, and water levels, could be detrimental

to fungi. At certain times, inorganic nutrients such as nitrates and phosphates are absent or present only in small quantities; this condition could limit fungal growth. One might expect that these periodically fluctuating environmental conditions could have selected for a small group of distinctive fungi particularly well adapted to the swamp habitat. As far as number of species, this appears not to be the case, because 147 species were found, although only two collection and incubation techniques were used. The use of different collection and incubation techniques could yield still more species.

Evidence of the presence of a distinctive group of fungi associated solely or primarily with swamps or swamp-like portions of other aquatic habitats such as lakes and bogs is somewhat limited. The number of indigenous species that occur in the swamps studied is quite high. Of the 147 species reported, two represent new genera known only from their type locations (*Aquadiscula appendiculata* and *Lepidopterella palustris*); nine species were described as new (*Diderma diademata*, *Zopfiella lundqvistii*, *Codinaea gonytrichodes*, *Endophragmiella boeweii*, *Melanocephala triseptata*, *Phialocephala illini*, *Sporidesmium taxodii*, *Taeniolella americana*, and *Trichochladium moenitum*); and 16 species remain to be described as new. Three of the above species have been reported from other habitats and geographical areas since their original description [*E. boeweii*, Japan, Formosa (Hughes, 1979); *T. moenitum*, Canada (Hughes, 1984) as *Bactrodesmium*); *C. gonytrichodes*, Japan (Yokoyama, 1975); Alabama (Morgan-Jones, 1976) as *Codinaeopsis*]. Whether all of the other new species eventually will be found in other habitats or only in swamps remains to be seen. Cultural studies of both indigenous and frequently-occurring species are warranted to determine whether these fungi have adapted to the swamp habitat in terms of nutrition and metabolism and are therefore physiologically distinctive.

Studies of small ponds have revealed a distinctive mycota thought to be adapted to stagnant water and fluctuating water levels (Fisher, 1977). These fungi are known as "aeroaquatic" fungi and produce vegetative mycelium in submerged substrata, and conidia with morphologies modified for flotation on unsubmerged moist substrata (Webster and Descals, 1981). Given the fluctuating water levels and stagnant water characteristic of swamps, one might expect to find a number of aeroaquatic fungi. Six species with air-trapping helical spores were found: *Helicodendron conglomeratum*, *H. triglitziensis*, *H. tubulosum*, *H. westerdykiae*, *Helicoon* sp. I, and *Vanbeverwijkia spirospora*. Three species, *Candelabrum brocchiatum*, *Pseudaegerita corticalis*, and CS-717-1 have highly branched and hydrophobic propagules, and two species, *Beverwykella pulmonaria* and *Cancellidium applanatum*, produce multicellular air-filled sacs. Production of buoyant propagules is advantageous in habitats with fluctuating water levels, such as swamps. When water levels decrease, these fungi are stimulated to sporulate and as water levels rise again, their propagules float off of substrata onto the surface of the rising water and are dispersed. Michaelides and Kendrick (1982) suggest that these buoyant propagules attach to fresh-fallen tree litter as it floats on the water surface. *Neta patuxentica*, one of the most common species, and *N. lignicola* both produce conidia in baskets of highly branched, interwoven dematiaceous hyphae which trap air. The clusters of conidia inside the hyphal baskets are not easily dislodged from the substratum. The net baskets may function more to trap air so conidiogenesis can occur than as flotation devices.

A number of fungi, *Chaetomium* spp., *Cladosporium* spp., *Trichoderma harzianum*, and *Penicillium* spp., were found to sporulate on the surfaces of water films. The hairs of *Chaetomum* spp. trap air and render the ascomata water repellent and buoyant. The conidia of *Cladosporium*, *T. harzianum*, and *Penicillium* are all very hydrophobic and lie as a fine powder on the surfaces of water films in dishes.

Only *Varicosporium* sp. I, *Filosporella* sp. CS-707-1, and *Pyrimadospora* sp. CS-575-4 were typical of the so-called "Ingoldian" fungi, that is, fungi with highly branched, tetraradiate or sigmoidal conidia found commonly in streams. Absence of a variety of "Ingoldian" fungi in swamps supports the prevalent concept that these fungi occur more abundantly in clean, fast-flowing water than in stagnant water habitats (Webster and Descals, 1981). Efforts are underway to use collection and incubation techniques more favorable to the recovery of aeroaquatic and "Ingoldian" Hyphomycetes to determine

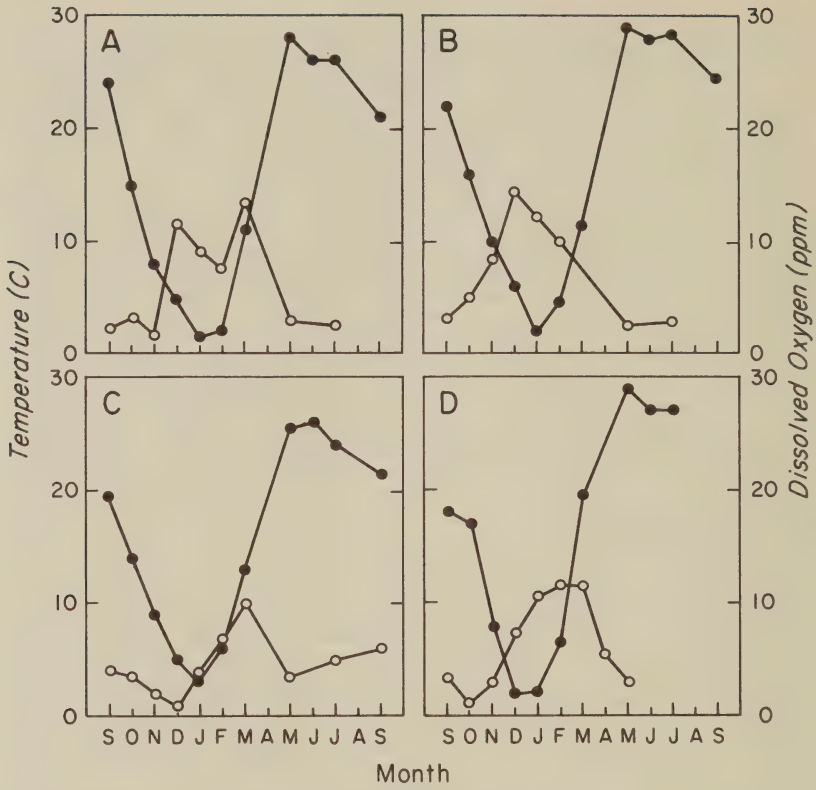

Fig. 1. Monthly temperatures and dissolved oxygen concentrations of surface waters in La Rue Swamp (A), Wolf Lake (B), Deer Pond (C), and Heron Pond (D). ●——● = Temperature. ○——○ = Dissolved oxygen.

whether additional species went undetected due to sampling procedures.

A large number of the Ascomycetes found (Table 2) have been reported from other freshwater, brackish, and marine habitats. The following species have been found in freshwater, brackish water, and marine habitats: *Aniptodera chesapeakensis* (Shearer and Miller, 1977; Minoura and Muroi, 1978; Kohlmeyer and Kohlmeyer, 1979; Shearer and von Bodman, 1983); *Halosarpheia retorquens* (Shearer and Crane, 1980b; Kohlmeyer, 1984); *Nais inornata* (Shearer and Crane, 1978b; Minoura and Muroi, 1978; Kohlmeyer and Kohlmeyer, 1979; Shearer and von Bodman, 1983; Koch and Jones, 1983; Zanial and Jones, 1984); and *Zopfiella latipes* (Shearer, 1972; Kohlmeyer and Kohlmeyer, 1979). *Luttrellia estuarina* has been reported from brackish and freshwater habitats (Shearer, 1978; Shearer and von Bodman, 1983). The following species have been reported from other freshwater habitats: *Cercophora* sp. I (Shearer and von Bodman, 1983), *Chaetomium cochlioides* (Apinis *et al.*, 1972), *C. globosum* (Eaton and Jones, 1971; Eaton, 1972), *Pseudohalonectria lignicola* (Shearer, 1972 as CS-182; Minoura and Muroi, 1978; Shearer and von Bodman, 1983), and *Trematosphaeria fallax* (Shearer, 1972). *Zalerion varium*, a Deuteromycete, has also been reported from brackish and marine habitats and inland salt lakes (see Kohlmeyer and Kohlmeyer, 1979 for summary).

A large number of the remaining species (Table 2) have been reported from decaying

plant material in predominantly terrestrial habitats. This is not surprising in view of the fact that swamps dry down and become terrestrial habitats usually once a year and also because swamps receive run-off from terrestrial habitats during flooding, no doubt an annual source of propagules of terrestrial fungi. The role and extent of activity of these fungi in swamps need to be investigated.

A surprising diversity of Myxomycetes occurred regularly. These organisms, although reported frequently on dead plant substrata, have not often been reported from freshwater habitats. Olive (1975) found that one of the most productive substrates for Myxomycetes is old cattail inflorescences. Cattails occur around the edges of ponds and swamps and in drainage areas, and it is possible that emergent macrophytes in the swamp are the habitat for the Myxomycetes collected. Quantitative study of a variety of swamp substrata located at various depths in the swamp is needed to pinpoint the types of substrata colonized by Myxomycetes, and to determine their patterns of occurrence with respect to degree of submersion and location in the habitat.

In addition to regular monthly sampling, the La Rue Swamp site #1 and Deer Pond sites were sampled three additional times in later years (1979, 1983, and 1984). Because these swamps were sampled simultaneously throughout, it is possible to compare the fungi found. Similar numbers of species were found in each swamp (La Rue Swamp site #1, 59 species; Deer Pond, 66 species). Of these species, however, only 19 occurred in both swamps. The low number of species in common may simply be due to chance; the probability of finding a rare species is low when samples are collected only at monthly intervals and thus the probability of finding a rare species in both swamps is even lower. On the other hand, actual differences in species composition between swamps may indeed exist. Given the differences in vegetational composition (see Description of Study Sites) and the fact that La Rue Swamp is spring-fed and attached to a large lake while Deer Pond is not, it is possible that the two swamps are sufficiently different to support different mycotas. Further detailed comparisons of these two swamps is warranted. Because of differences in number and type of samples taken, comparisons between the other sites cannot be made now.

Although samples were collected regularly over an annual cycle, little can be said regarding seasonal changes because fungi were not sampled quantitatively and incubation conditions did not reflect seasonal changes in environmental parameters. A quantitative comparison of the fungi in La Rue Swamp and Deer Pond over an annual cycle is planned.

ACKNOWLEDGMENTS

We thank J. D. Schoknecht for the identification of the Myxomycetes.

Table 1. Ranges in physical-chemical water quality parameters.

Parameter	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond
Temperature (°C) (13 samples)	1.5–28.0	2.0–29.5	2.0–29.0	2.0–31.0	3.0–28.0
DO_2 (mg/l)	1.0–13.5	2.4–11.7	2.4–14.5	1.3–11.5	1.01–10.0
pH	3.6–7.5	5.5–7.5	3.5–6.8	6.0–7.4	5.2–7.0
EDTA hardness (mg/l)	30.0–117.0	6.0–94.0	33.0–150.0	<3.0–67.0	12.0–62.0
NH_3 (mg/l NH_3-N)	0.18–15.2	<0.05–1.56	3.8–7.3	0.08–6.3	0.05–2.55
NO_2 (mg/l NO_2-N)	0.0–0.03	<0.01–0.09	<0.01–0.28	0.0–0.01	0.0–0.01
NO_3 (mg/l NO_3-N)	0.0–5.2	0.0–<0.01	0.09–10.3	0.0–<0.05	0.0–<0.05
PO_4 (mg/l ortho-PO_4)	0.05–6.66	0.02–0.90	0.02–0.48	0.07–2.31	0.013–0.54

Table 2. Herbarium and/or collection numbers of voucher specimens and sites of occurrence for all species collected.

Species	Herbarium or collection #	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond	Goose Pond	Forman Swamp
Myxomycetes								
Acyria denudata (L.) Wettst.	36,047						+	
Comatrichia tenerrima (M. A. Curt.) G. Lister	38,643				+			
Cribaria violacea Rex	44,811	+						
Cribaria tenella Schrad.	36,583	+						
Diderma diademata Schoknecht & Crane	37,665	+				+	+	
Didymium trachysporum G. Lister	38,600	+	+	+	+		+	
Metatrichia vesparum (Batsch) Nann.-Brem.	36,581	+			+			
Oligonema flavidum (Peck) Peck	38,130				+	+	+	
Oligonema schweinitzii (Berk.) G. W. Martin	36,742					+		
Perichaena chrysosperma (Currey) A. Lister	44,812	+						
Perichaena corticalis (Batsch) Rost.	38,012	+	+					
Perichaena depressa Libert	36,099						+	
Stemonitis smithii Macbr.	36,100						+	
Ascomycetes								
Aniptodera chesapeakensis Shearer & Miller	44,779			+				
Aquadiscula appendiculata Shearer & Crane	44,301	+						
Bisporella citrina								

Table 2. (cont'd)

Species	Herbarium or collection #	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond	Goose Pond	Forman Swamp
(Batsch:Fr.) Korf & Carpenter	36,046						+	
Ceratosphaeria pusilla (Fckl.) Sacc.	44,364					+		
Cercophora sp. I	39,916	+		+		+		
Chaetomium aureum Chivers	42,883	+						
Chaetomium cochliodes Palliser	44,777					+		
Chaetomium funicolum Cooke	37,059				+	+		
Chaetomium globosum Kunze:Fr.	42,908					+		
Chaetomium seminudum Ames	39,930					+		
Chaetomium trilaterale Chivers	43,768			+		+		
Chaetomium sp. I	42,907	+						
Chaetomium sp. II	42,904		+					
Coniochaeta kellermani (Ell. & Ev.) Munk	37,699				+			
Coniochaeta leucoplaca (Berk. & Rav.) Cain	43,771						+	
Coniochaeta velutina (Fckl.) Munk	37,049						+	
Emericellopsis humicola (Cain) Gilman	36,103		+					
Gnomonia sp.	44,764					+	+	+
Halosarpheia retorquens Shearer & Crane						+		
Halosarpheia sp. I	44,768	+		+				
Lepidopterella palustris Shearer & Crane	38,991					+		
Luttrellia estuarina Shearer	44,776							
Nais inornata Kohlm.	37,389	+				+		
Ophioceras sp. I	CS-408-1	+						
Passeriniella discors (Sacc. & Ellis) Apinis & Chesters	38,393					+		
Pseudohalonectria lignicola Minoura & Muroi	44,767		+			+		
Pseudohalonectria sp. I		+		+				
Rabentischia unicaudata (Berk. & Br.) Sacc.	44,775		+					
Sordaria sp. I.	44,791	+	+					
Sordaria sp. II	36,969			+				
Talaromyces flavus (Klocker) Stolk & Samson var. *flavus*	36,386	+		+	+	+		
Trematosphaeria fallax Mouton	43,804	+						
Zopfiella latipes (Lundqvist) Malloch & Cain	39,682	+	+	+	+	+		
Zopfiella lundqvistii Shearer & Crane	39,933	+			+	+		
Fungi Imperfecti								
Acremonium bacillisporum (Onions & Barron) W. Gams	43,808				+			
Acrogenospora sphaerocephala (Berk. & Br.) M. B. Ellis	37,022					+		
Allescheriella crocea (Mont.) Hughes	36,678	+		+	+	+		
Alysidium aureofulvum (Cooke & Ellis) M. B. Ellis	37,112					+		
Arthrobotrys superba Corda	36,009	+						
Berkleasmium concinnum (Berk.) Hughes	37,053				+			
Bactridiopsis sp.	44,759				+			

Table 2. (cont'd)

Species	Herbarium or collection #	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond	Goose Pond	Forman Swamp
Beverwykella pulmonaria (Van Beverw.) Tubaki	38,473	+			+			
Bispora betulina (Corda) Hughes	37,055	+		+	+	+		
Cancellidium applanatum Tubaki	45,220						+	
Candelabrum brocchiatum Tubaki	37,178				+			
Chloridium botryoideum (Corda) Hughes	44,784	+				+		
Chloridium chlamydosporis (Van Beyma) Hughes	36,731			+				
Chloridium clavaeforme (Preuss) W. Gams & Hol. Jech.	36,901	+		+			+	
Chloridium virescens (Pers.:Fr.) W. Gams & Hol. Jech.	39,657	+			+	+		
Cladosporium sp.		+						
Cladosporium cladosporioides (Fresen.) de Vries	43,813					+		
Cladosporium oxysporum Berk. & Curt.	36,045					+		
Codinaea gonytrichodes Shearer & Crane	37,039					+		
Codinaea simplex Hughes & Kendrick	42,243				+	+		+
Codinaea anam. of *Chaetosphaeria talbotii* Hughes, Kendrick & Shoemaker	43,817				+			
Conioscypha lignicola Hoehnel	37,052	+		+	+	+		
Conioscypha varia Shearer	36,535	+		+	+	+		
Dactylaria chrysosperma (Sacc.) Bhatt & Kendrick	44,781					+		
Dactylaria purpurella (Sacc.) Sacc.	36,379	+			+	+		
Dendrophoma sp.	44,783	+						
Dendrosporium lobatum Plakidas & Edgerton ex Crane	34,949					+		
Dendryphiopsis atra (Corda) Hughes	44,225					+		
Endophragmiella boewei (Crane) Hughes	44,770					+		
Eversia subopaca (Cooke & Ellis) Crane & Schoknecht	45,219					+		
Gliocladium deliquescens Sopp	36,745					+		
Gliomastix murorum (Corda) Hughes	36,381			+	+			+
Gonytrichum macrocladium (Sacc.) Hughes	43,812		+	+	+	+		
Hainesia sp.								
Helicodendron conglomeratum Glen-Bott	38,472	+						
Helicodendron triglitziensis (Japp) Linder	36,007						+	
Helicodendron tubulosum (Reiss) Linder	44,778					+		
Helicodendron westerdykiae Beverwijk	43,789	+						
Helicoon sp.						+		
Hormiactis sp. I	43,811	+						
Melanocephala triseptata (Shearer, Crane & Miller) Hughes	40,806					+		

Table 2. (cont'd)

Species	Herbarium or collection #	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond	Goose Pond	Forman Swamp
Microsphaeropsis sp.	44,788	+						
Monacrosporium sp.	45,230							+
Neta lignicola Shearer	44,765					+	+	+
Neta patuxentica Shearer & Crane	36,050	+		+	+	+		
Penicillium sp.	44,756		+					
Phaeoisaria clematidis (Fuckl.) Hughes	39,680			+		+		
Phialocephala bactrospora Kendrick	42,224		+					
Phialocephala humicola Jong & Davis	36,585			+				
Phialocephala illini Crane	34,911					+		
Phialophora radicicola Cain	44,774	+						
Phialophora richardsiae (Nannf.) Conant	36,587	+		+		+		
Phialophora verrucosa Medlar	44,897					+		
Phoma sp.	44,771			+				
Pleurothecium recurvatum (Morgan) Hoehnel	43,810			+				
Pyrenochaeta sp.						+		
Pseudaegerita corticalis (Peck) Crane & Schoknecht	43,815		+			+		
Rhinocladiella anceps (Sacc. & Ellis) Hughes			+					
Sclerotium rolfsii Sacc.	44,790	+		+	+	+		
Scolecobasidium constrictum Abbott	36,008					+		
Selenosporella sp.						+		
Spadicoides atra (Corda) Hughes	38,122				+			
Spadicoides bina (Corda) Hughes	38,123				+			
Sporidesmium hyalospermum (Corda) Hughes	36,837			+	+	+		
Sporidesmium taxodii Crane	34,936						+	
Sporoschisma mirabile Berk. & Hughes	36,880	+						
Sporoschisma saccardoi Mason & Hughes	43,764				+			
Stachybotrys cylindrospora Jensen	38,128				+			
Staphylotrichum coccosporum Meyer & Nicot	36,006	+				+		
Stilbella erythrocephala (Ditmar:Fr.) Lindau	44,758					+		
Taeniolella americana Crane & Schoknecht	41,016						+	
Thozetella tocklaiensis (Agnih.) Pirozynski & Hodges	36,781	+	+	+	+	+		
Torula herbarum (Pers.) Link:Fr.	43,795	+		+				
Trichocladium lobatum Sutton	37,179				+			
Trichocladium moenitum Crane & Shearer	38,121				+			
Trichoderma harzianum Rifai	36,024	+		+		+		
Vanbeverwijkia spirospora Agnihotrudu	44,898					+		
Varicosporium sp. I		+						
Verticillium sp. I	44,760					+		
Virgaria nigra (Link:Fr.) Nees	43,765					+		
Wiesneriomyces laurinus (Tassi) P. M. Kirk	43,801	+	+					

Table 2. (cont'd)

Species	Herbarium or collection #	Location: La Rue site #1	La Rue site #2	Wolf Lake	Heron Pond	Deer Pond	Goose Pond	Forman Swamp
Xylohypha sp.	44,762							
Zalerion varium Anastasion	44,786					+		
Basidiomycetes								
Vararia pallescens (Schw.) Rogers & Jackson	44,801					+		
Undescribed Species of Fungi Imperfecti								
Filosporella sp.	CS-707-1	+						
Pyrimadospora sp.	CS-754-1	+						
Spadicoides sp.	CS-754-1	+						
CS-717-1		+						
CS-750-1		+						
Undescribed Species of Ascomycetes								
CS-429-1				+				
CS-589-1						+		
CS-603-1						+		
CS-733-1		+						
CS-734-1		+						
CS-735-1		+						
CS-746-1		+						
CS-747-1						+		
CS-749-1		+						
CS-751-1		+						
CS-753-1		+						

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MYCOTAXON

Vol. XXV, No. 2, pp. 539-567 April-June 1986

SOME NEW AND NOTEWORTHY FUNGI (APHYLLOPHORALES, BASIDIOMYCETES) FROM IGUAZU, ARGENTINA

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SUMMARY

46 species of corticoid fungi are reported from Iguazu National Park, Argentina. The following new taxa are described: Coniophoropsis and Gloeocorticium nov. gen. Coniophoropsis obscura, Amethicium luteo-incrustatum, Candelabrochaete cirrata, C. dispar, Gloeocorticium cinerascens, Gloeocystidiellum triste, Hyphoderma iguazuense, Hyphodontia lutescens, H. tenui-cystidiata, H. wrightii and Odonticium helgae. The following new combinations are proposed: Cystidiodontia isabellina (Berk. & Br.) Hjortst. & Ryv., Fibricium subceraceum (Hallenb.) Bern. and Hyphodontia apacheriensis (Gilbn. & Canf.) Hjortst. & Ryv.

During a course in mycology which was arranged by the University of Buenos Aires, one of us (LR) had the opportunity to make some 580 collections, mostly polypores and corticoid species, from Iguazu National Park. It is situated in the province of Misiones in Northern Argentina and its main attraction is the enormous Iguazu waterfall on the border between Brazil and Argentina. However, there are also in the National Park extensive forests which are fairly accessible.

Several mycology courses have been given in the park, some groups of fungi such as the polypores are well known, while the corticoid species had previously not been collected and studied. Thus, the polypores are omitted, while all corticoid collections that have been determined

are included in the list. Some genera like Phlebia s. lato are excluded, because more type studies are necessary before a reliable determination can be reached in this group.

The families are placed alphabetically as are the genera within each family. All collections were made in the period 1-7 March 1982. After the name, the collection number is cited. All collections are deposited in Oslo (O), while there are duplicates of the more remarkable collections in Buenos Aires.

Coniophoraceae.
Coniophoropsis Hjortst. & Ryv. gen.nov.
Coniophora aemulans, differt sporis distincte verruculosis, indextrinoidibus.
Type species: Coniophoropsis obscura Hjortst. & Ryv. spec. nov. Fig. 1.
Habitu plus minus specierum Coniophoracearum, praecipue differt sporis verruculosis.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat.Park, Cataratas de Iguazu. 1-5 March 1982. L. Ryvarden No. 19677 (O). Isotypus:(GB and a portion of this in DAOM No. 188783).

Fruitbody effuse, closely adnate, smooth, effused, 0.3-0.5 mm thick, margin narrow, whitish or paler than the fertile part, hymenium brown-violet, in older parts brown with a olive tint, hyphal strands lacking in the type specimen; subiculum well separated from the hymenial layer, 0.1-0.2 mm thick, whitish, fairly loose and soft. Hyphal system monomitic; hyphae thin-walled, hyaline or some hyphae with slight yellowish tint, approximately 2.5 µm wide, without clamps, smooth or sparsely encrusted, subicular hyphae next to the substratum more or less closely packed, hyaline or more commonly yellowish, 2.5-4.5 µm wide, no clamps observed. Cystidia lacking but with protruding hyphoids (dendrohyphid-like element) above the basidia, with few, more or less perpendicular short branches. Basidia cylindrical to more or less suburniform with a median constriction, generally tapering near the base, usually 50 µm long and 10-12 µm wide in the upper part, thin-walled and normally with 4 sterigmata, young basidia with oily contents in the protoplasm. Spores subfusiform to subamygdaliform, verrucose, distinctly thick-walled with spore-walls yellowish-brown and about 0.5 (1) µm thick, without colour change in Melzer but strongly cyanophilous, 15-18(-20) x 7.5-9(-10) µm, apiculus fairly small, usually more or less hyaline and apparently with a germ-pore but difficult to discern.

Remarks. This monotypic genus differs from all other genera in Coniophoraceae by its verruculose spores. The morphology of Coniophoropsis obscura is more or less as for species in Coniophora, but some noteworthy microscopic

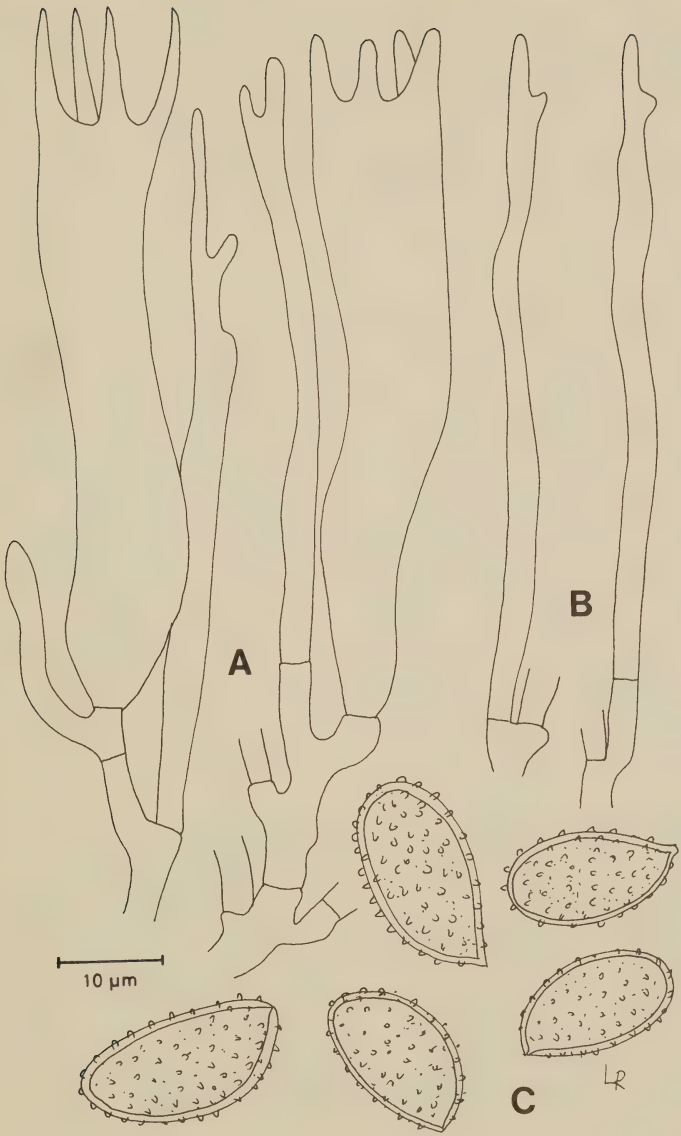

Fig. 1. **Coniophoropsis obscura** A) basidia, B) hyphoid elements, C) spores. From the holotype.

differences, except the spores, should be noted. The apiculus is smaller and the germ-pore is very difficult to observe. Hyphal ends, or indistinctly differentiated dendrohyphidia, project slightly above the basidia. It should be mentioned, however, that such hyphae also occur, at least occasionally, in fruitbodies of Coniophora species. The dextrinoid reaction of the spores is not noticeable, while this characteristic is easily noted in most species of Coniophora. Verticillate or scattered clamps on the basal hyphae occur regularly in Coniophora but have not been observed in Coniophoropsis.

Corticaceae

Amethicium luteo-incrustatum Hjortst. & Ryv. spec. nov. Fig. 2.
Fructificatio resupinata, arcte adnata, stratosa, sordide flava vel brunneola, circiter 0.2-0-6 mm crassa; hymenio levi vel passim tuberculato; systema hyphale dimiticum; subiculum distinctum, leve, 0.2-0.4 mm crassum, dilute ochraceum, hyphis skeleticis ramosissimis, perangustis, 0.5-1 µm crassis, ut videtur tenuitunicatis, hyalinis, fibulis nullis, indextrinoidei; hyphae generatoriae tenuitunicatae, 2-2.5 µm, hyalinae vel luteolae incrustatae, fibulatae, hyphae subhymeniales indistinctae, agglutinatae, itidem fibulatae; cystidia conspicua, tenuitunicata, plus minus cylindracea, basaliter valde luteola incrustata, generaliter 70-100 x 5-8 µm; in hymenio hyphae cystidioideae (basidiolae) dispositae, plus minus subulatae, 20-30 x 3.5-4 µm; basidia subclavata, tenuitunicata, 20-40 x 4-4.5 µm, 4 sterigmatibus; sporis ellipsoidei, tenuitunicatis, levibus, 4.5-5 x 2.8-3 µm, neque amyloidei et cyanophilis, neque dextrinoidei. Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park, Cataratas de Iguazu, 1-5 March 1982. L. Ryvarden No. 19529 (O). Isotypus: (GB, and in Hjm priv.herb.).

Fruitbody resupinate, closely adnate, about 0.2-0.6(-1) mm thick, more or less membranaceous, crustaceous, fairly brittle and easily squashed under a cover glass, stratified, with 2 or more zones above the subiculum, hymenium smooth to slightly tuberculate, dotted by reddish encrusted cystidia (very strong lens, x 100), sordidly yellow or brownish, margin soft and byssoid. Hyphal system dimitic with a very distinct, pale ochraceous subiculum separated from the hymenium by a brown sterile zone consisting of hyphae and cystidia-residua, about 0.2-0.4 mm thick, soft, skeletal hyphae 0.5-1 µm wide, hyaline, thin-walled, without clamps, generative hyphae wider, with clamps, up to 2-2.5 µm or more, hyaline or heavely encrusted with resinuous and yellowish matter.

Cystidia abundant, usually projecting 10-20 µm above the basidia, flexuose, tapering towards the obtuse tip, basally strongly encrusted with yellowish, resinuous

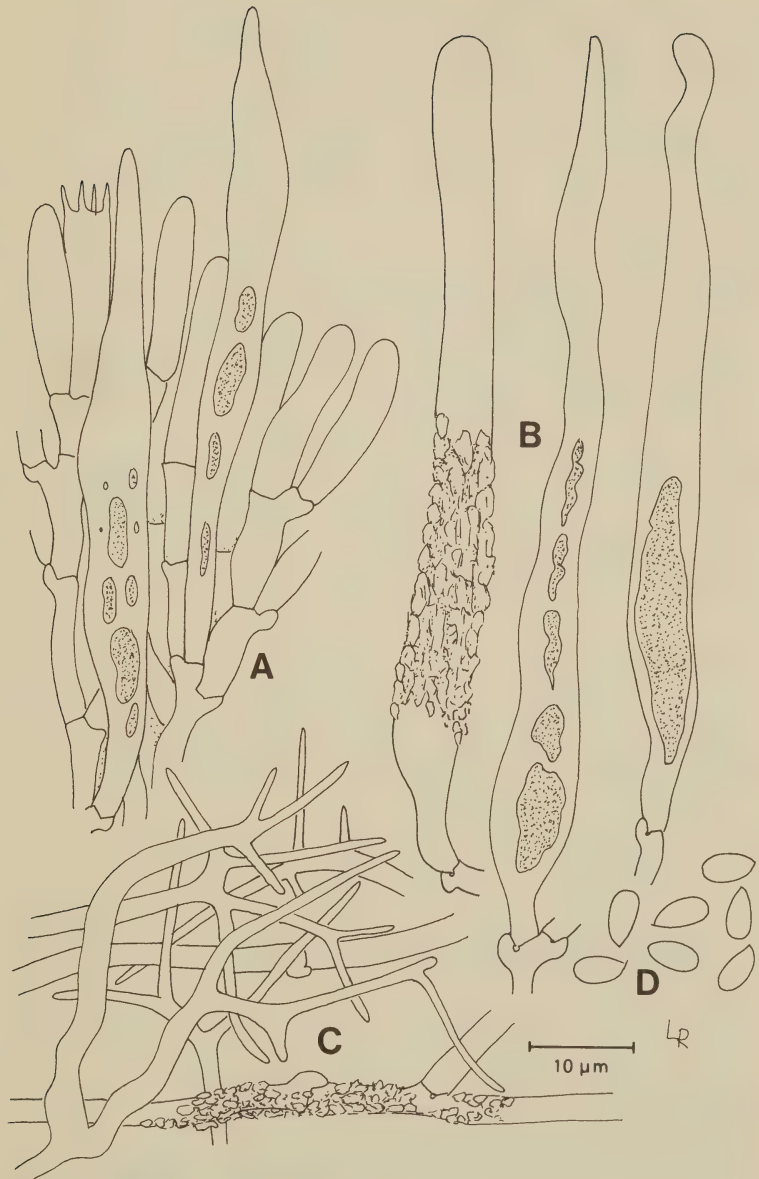

Fig. 2. **Amethicium luteo-incrustatum** A) part of hymenium with cystidia, B) cystidia, C) arboriform skeletal hyphae and generative hyphae from the subiculum, D) spores. From the holotype.

matter, 70-100 x 5-8 µm, cystidioles scattered in the hymenium well differentiated from the basidia, 20-30 x 3.5-4 µm, more or less subulate and broadest above the middle. Basidia subclavate in a dense tissue, 20-40 x 4-4.5 µm, thin-walled, with four sterigmata and a basal clamp. Spores narrowly ellipsoid, smooth, thin-walled, 4.5-5 x 2.8-3 µm.
Remarks. This is a conspicuous species and above all characterized by the loose subiculum and cystidia with yellowish encrustation.

Amethicium (Hjortstam 1983) was based on an African species (A. rimosum) with violaceous colour and dimitic hyphal system, but without cystidia. A. luteo-incrustatum is in many respects similar to A. rimosum by the similar skeletal hyphae, the loose subiculum, the dense basidial layer and the morphology of the spores. Except for the striking subiculum with skeletal hyphae, the species is similar to some in Phlebia s.l.

Asterostroma andinum Pat. 19578, 19616, 19728/B.
The concept is according to Parmasto (1979). An important characteristic is the asteroseta which have one ray projecting above the hymenium and easily observed under a strong lens giving the impression of an hymenochaetaceous fungus. The knowledge of species and the variation within the species in Asterostroma is far from satisfactory and a revision of the tropical taxa is especially needed.

A. cervicolor (Berk. & Curt.) Massee 19601, 19629, 19630, 19739.
The concept of this species is slightly vague, and we have used this name in a wide sense mainly as it has priority of such names as A. medium Bres. and A. ochroleucum Bres.
Athelopsis aff. lembospora (Bourd.) Oberw. 20069.
The collection differs from the original concept by longer spores, up to 10 µm long.

Botryobasidium lembosporum (Rog.) Donk 19659, 19721, 19849, 20045, 20104.
The anamorph is not connected in any of the specimens.

Botryohypochnus hebelomatosporus Boid. & Gilles 19854.
Previously known only from Africa (Gabon) from where it was described. Boidin has kindly confirmed the determination.
The species has a somewhat isolated place in the genus, above all by its conspicuous and Hebeloma-like spores.

Byssomerulius hirtellus (Burt) Parm. 19641.
This specimen is determined by J. Ginns as "very similar to Merulius hirtellus Burt".
There is a very slight difference in the shape of the spores which tend to be adaxially concave and somewhat narrower. Cystidia (or hyphoids) occur but are very few or

difficult to observe as they resemble of undeveloped basidia, though being slightly narrower.

Candelabrochaete Boid. subgen. Botryodontia Hjortst. & Ryv. subg. nov.
ex affinitate Candelabrochaete a qua impromis differt rhizomorphis praesens, basidiis brevibus et aliquantum obconicis.
Typus: Candelabrochaete cirrata Hjortst. & Ryv.

Candelabrochaete cirrata Hjortst. & Ryv. spec. nov.
Fig. 3.
Fructificatio resupinata, laxe adnata, plus minus caespitosa; aculeis parvis, constans ex hyphis sterilibus; systema hyphale dimiticum vel duplex; rhizomorphae conspicuae, albidae, ex hyphis crassitunicatis, dilatatis vel tenuitunicatis, alteruteris dilatatis vel angustis, tum 1.5-3 µm latis, sine fibulis; hyphae ceterae tenuitunicatae vel crassiusculae, 5-7 µm latae, passim incrustatae, sine fibulis; cystidia sparsa, clavata, circiter 40x10 µm, tenuitunicata; basidia brevia, plus minus obconica, circiter 17 x 6-7 µm, 4 sterigmatibus; sporis ellipsoidei, levibus, tenuitunicatis, indextrinoidei.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park, Cataratas de Iguazu, 1-5 March 1982. L. Ryvarden No. 19572, on lower side of leaves (O). Isotypus: (GB).

Fruitbody resupinate, loosely adnate, thin, almost arachnoid, tufted and provided with small aculei consisting of sterile hyphae, whitish. Rhizomorphs conspicuous, consisting of at least two types of hyphae: 1) thick-walled and fairly wide, with frequent septa 2) thin-walled or with slight wall thickening, narrow, about 1.5-2.5(-3) µm wide, seemingly septate. Other hyphae correspond with those in the fruitbody, viz. thin-walled and about 5-7 µm wide. Aculeal hyphae distinct, arising from the very thin subiculum, thin or moderately thick-walled, often encrusted with crystalline matter, all hyphae without clamps. Cystidia scattered, clavate, generally 40 µm long and 10 µm wide in the upper part. Basidia short, as a rule obconical, about 17x6-7 µm, with 4 sterigmata. Spores ellipsoid, smooth, thin-walled, 6-6.5 x 4-5 µm, often with one or several oildrops in the protoplasm, without amyloid, dextrinoid or cyanophilous reaction.
Remarks. This species differs from all others in the genus by its rhizomorphs with some kind of skeletal hyphae. Most hyphae in well developed rhizomorphs are thick-walled, up to 5-7 µm wide or narrow and 1.5-3 µm wide. The morphology of basidia is striking and as a rule they are typically obconical, never elongated with median construction as in the generic type (C. africana). In looking for a suitable genus for this new species, Candelabrochaete was chosen as the most appropriate one. The differences in basidia and

hyphae seem to justify a subgeneric treatment.

Candelabrochaete dispar Hjortst. & Ryv. spec. nov. Fig. 4.
Quod habitum et fabricum internam fructificationem ad Candelabrochaeten africanam et verruculosam, a qua imprimis differt sporis globosis.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park, Cataratas de Iguazu. 1-5 March 1982. L. Ryvarden No. 19549 (O). Isotypus: (GB). Paratypi: 19564, 19580(O,GB).
Etymology: dispar - unlike
Fruitbody resupinate, closely adnate, when dried fragile and slightly cracked, creamish to pale ochraceous, about 0.2-0.4 mm thick, hymenium grandinioid to indistinctly odontioid with blunt aculei, cystidia somewhat projecting, hyaline and glittering, margin more or less abrupt or thinning out to a net of hyphae. Hyphal system monomitic, basal hyphae thin-walled or with thickened walls, rarely distinctly thick-walled, approximately 4-6 µm wide, branching at right angles or from an angle of 30°, long-celled and generally up to 50-80 µm between septa, subhymenial hyphae short-celled, branching in a candelabralike manner and often widest in the middle part, 4-5 µm wide, all hyphae without clamps. Cystidia tubular, thin-walled or basally with thickened walls, projecting up to 40-60 µm above the basidia, normally with 4-8 septa, about 80-120(-200) µm long and 6-9(-10) µm wide, acyanophilous.
Basidia short-clavate to almost cylindrical, (12-)15-17(-25) x 4-5(-6) µm, with four sterigmata, linear repetition not observed. Spores subglobose, smooth, thin-walled, 5-5.5 x 4-4.5 µm or about 5 µm in diam., inamyloid, indextrinoid, acyanophilous, often with a central oildrop (cotton-blue.)
Remarks. Externally this species is somewhat similar to both C. africana Boid and C. verruculosa Hjortst., but microscopically well separated by the different spores. Thin-walled conidia-like cells have been observed in all collections. In shape they are similar to the basidiospores but slightly smaller and usually born in short chains.

Cystidiodontia Hjortst., Mycotaxon 17 p.571, 1983.

This genus was described to accomodate Hydnum artocreas Berk. & Curt. ex Cooke. Unfortunately the description was based on East African specimens which later on appeared to be distinctly separated from the type of H. artocreas (Venezuela. No. 139, Kew). Thus, Cystidiodontia is a misapplied name and therefore a necessary generic emendation is given below.
The African material belongs to Kneiffia isabellina Berk. & Br. which primarily differs by its dextrinoid hyphae (skeletals). In most other characteristics such as gloeocystidia, basidia, and spores it is very similar to H. artocreas.

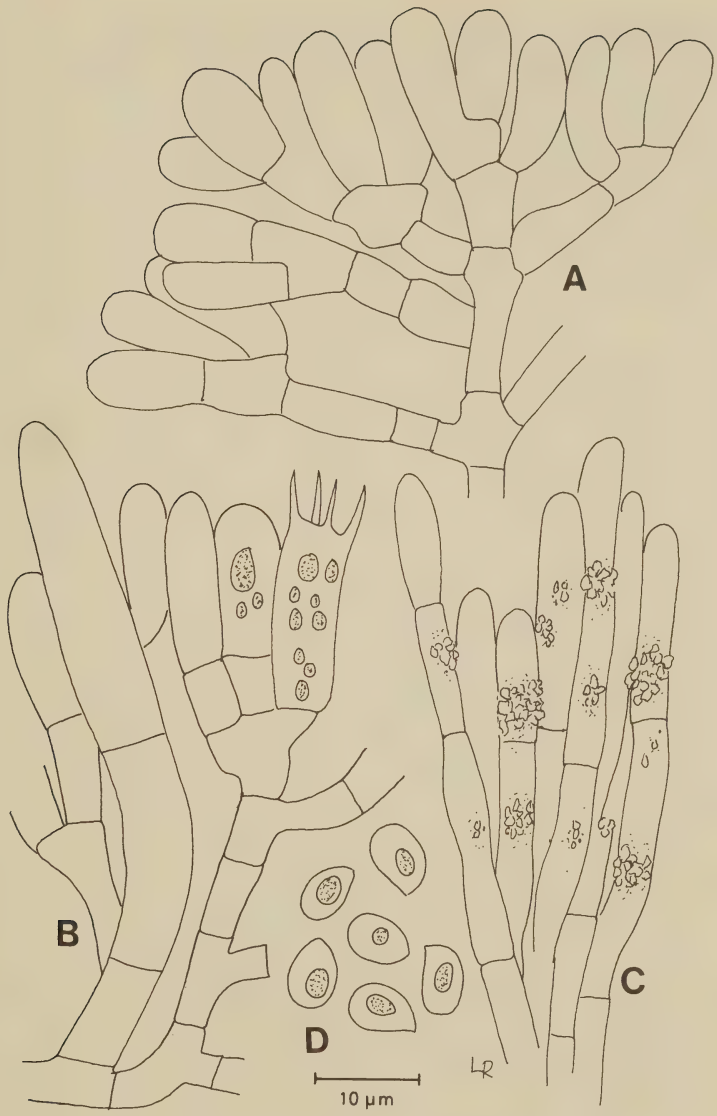

Fig. 3. **Candelabrochaete cirrata** A) cluster of unripe basidia, B) part of hymenium with cystidium, C) slightly encrusted aculeal hyphae, D) spores. From the holotype.

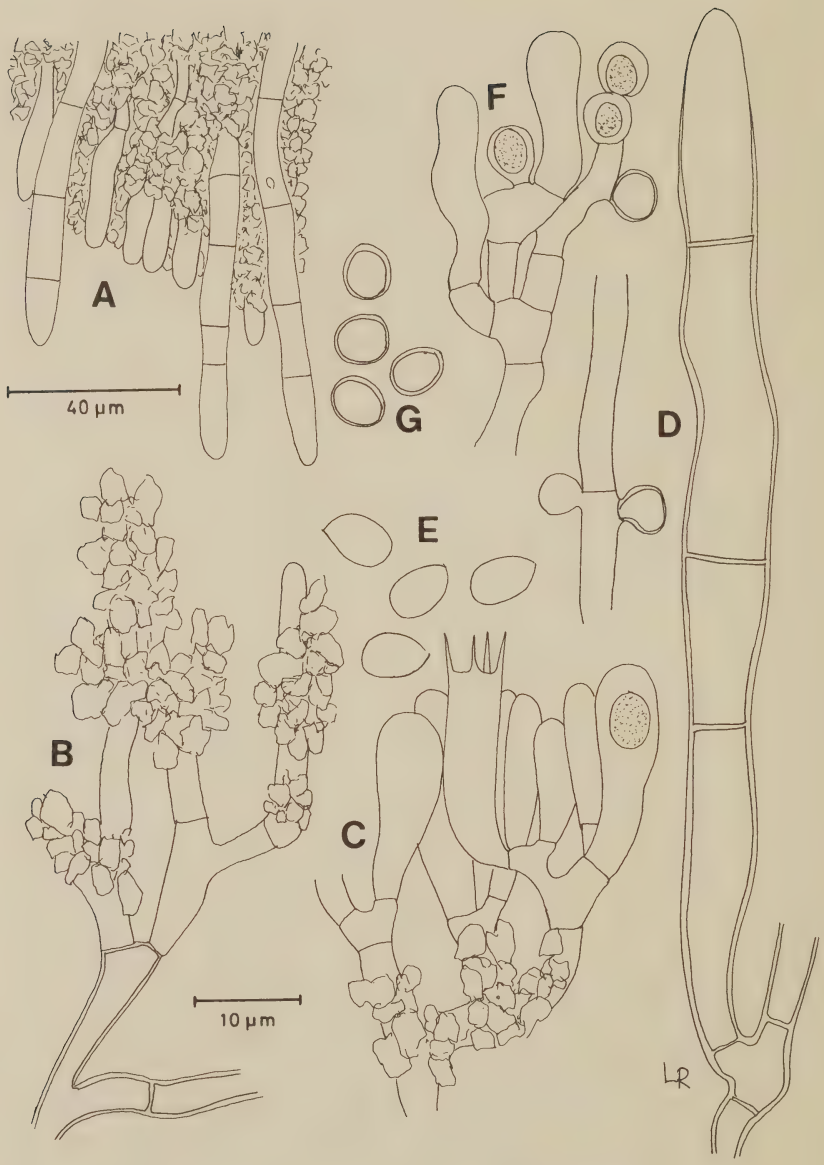

Fig. 4. **Candelabrochaete dispar** A) section through aculeus, B) encrusted hyphae from aculei, C) part of hymenium, D) cystidium, E) basidiospores, F) hyphae with condidia-like cells, G) separate conidia-like cells. From the holotype.

Emendation: Fruitbodies resupinate, closely adnate, crustaceous, hymenium grandinioid, odontioid or hydnoid; hyphal system dimitic, skeletal hyphae indextrinoid or strongly dextrinoid, without clamps, subhymenial hyphae thin-walled or with slight wall thickening, with clamps, gloeocystidia as a rule numerous, with yellowish contents, negative in sulfuric benzaldehyde, dendrohyphidia in the hymenial layer lacking or present; basidia subclavate, small to medium-sized, more or less constricted, with 4 sterigmata and a basal clamp; spores moderately thick-walled, subglobose, fairly small, about 3-4 x 2.5-3 µm, indextrinoid, inamyloid but with a slight cyanophilous reaction.

Cystidiodontia artocreas (Berk. & Curt. ex Cooke) Hjortst. Fig. 5.
- Hydnum artocreas Berk. & Curt. ex Cooke, Grevillea 20 p. 1, 1891. - nec Hydnum artocreas Berk., in Massee Journ. Bot. p. 163, 1892 = Hydnum indicum Sacc. & Syd. 1899. - necuaquam Hallenb. & Ryv. 1975, neque non Hjortst. 1983 = Kneiffia isabellina Berk. & Br. 1875.
Specimens seen: 19676, 19747, 19759. Additional specimens: Venezuela. No. 139 (K). Sao Leopoldo 1906. leg. J. Rick No. 106 (S, BPI, UPS).

Fruitbody resupinate, effused, odontioid to hydnoid or subporoid at the margin, light greyish brown, margin thinning out, somewhat byssoid, paler than the fertile part, aculei conical to flattened, simple or usually crowded and coherent, smooth or provided with small outgrowths, under a strong lens (X100) dotted by brownish excretions from the cystidia. Hyphal system dimitic; generative hyphae thin-walled, hyaline, intermingled with skeletals, all septa with clamp, subhymenial hyphae forming a dense and thin layer below the basidia, with clamps but difficult to observe. Skeletal hyphae dominating in the central part of the aculei but can also be found in the thin subiculum next to the substratum, thick-walled, hyaline, with adventitious septa but without clamps, transitions from generative hyphae often seen, 2-2.5 µm wide, indextrinoid and acyanophilous. Cystidia (Gloeocystidia) numerous and easily observed because of their yellowish content, strongly stained in cotton-blue, sinuous, thin-walled, negative in sulfuric benzaldehyde, about 20-30(-50) x 5-7 µm, with a basal clamp. Basidia small, with a median constriction, thin-walled, 10-12(-15) x 4-4.5 µm, eith 4 sterigmata and a basal clamp. Spores subglobose, smooth, moderately thick-walled, 3-3.2 x 2.5-2.8 µm, with weak cyanophilous reaction.

Cystidiodontia isabellina (Berk. & Br.) Hjortst. & Ryv. comb.nov. Basionym: Kneiffia isabellina Berk. & Br., Journ. Linn. Soc. Bot. Lond. 14 p. 62, 1875.
For detailed description see Hallenberg and Ryvarden, 1975. On the "type-sheet" of this species are three

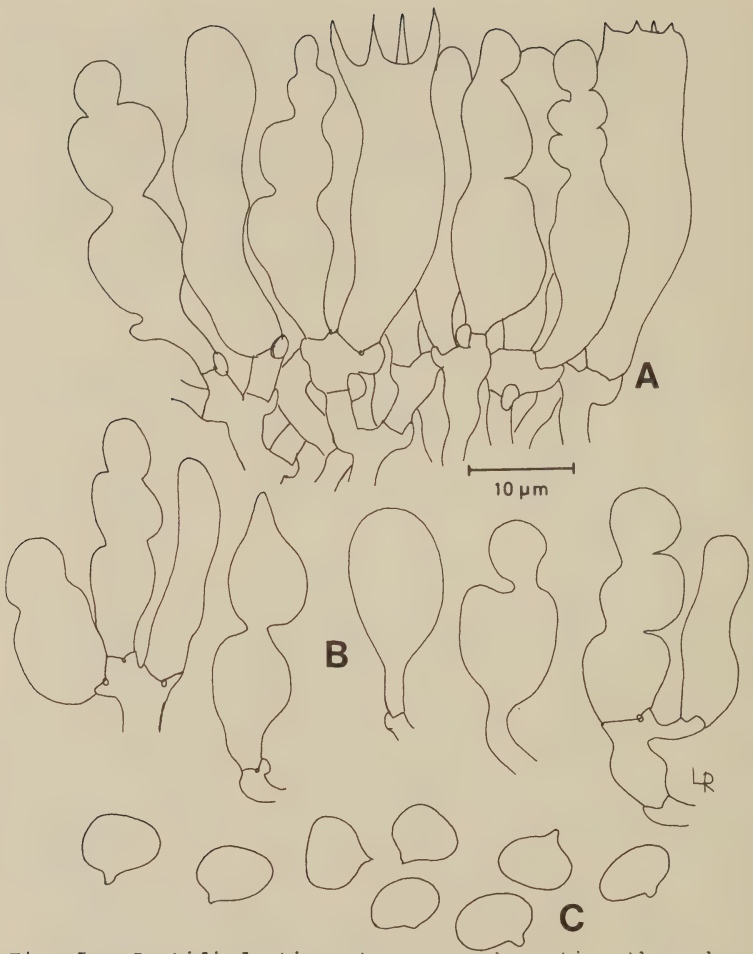

Fig. 5. **Cystidiodontia artocreas** a) section through fruitbody with positions of sections b and c, b) section through aculeus, c) cross-section through aculeus, d) skeletal hyphae, e) basidia, f) gloeocystidia. Coll. R. 19676. Drawing by J. Eriksson.

2-3(-4) µm wide, with clamps, subiculum thin to almost indistinguishable with somewhat agglutinated the hyphae. Cystidia conspicuous, strongly constricted to moniliform, apically often with one or several smaller protuberances, generally 20-40 µm long, distinctly amyloid, negative in sulfuric benzaldehyde. Basidia more or less clavate, thin-walled, slightly constricted in the middle part, about 20-25 x 6-7 µm, with 4 sterigmata and a basal clamp. Spores ellipsoid, thin-walled or with very slight

specimens indicated by us as A^1, A^2, and B. Specimens A^1 and A^2 are from: South of the island (Sri Lanka) July 1868, and Central province, Dec. 1868. They very likely represent what Berkeley had in hand when he described the fungus. The third specimen (B) has nothing to do with the two others and we have no name for it, but it is determined by Berkeley as Kneiffia setigera Fr. This latter species is collected in the same locality as K. isabellina and listed as no. 565.
Lectotypus: designated here, Ceylon, No. 655 A^1 (K).
It should be noted that this species is well known from eastern Africa and is hitherto not found in South-America. Its macromorphology is similar to that of C. artocreas, but is separated from the latter by microscopical characters.

Dendrodontia bicolor (Talbot) Hjortst. & Ryv. 19658.
Previously known only from Africa, Natal (Pietermaritzburg, type-locality), Kenya and Tanzania.
Fibricium subceraceum (Hallenb.) Bernicchia comb. nov.
Basionym: Fibrodontia subceracea Hallenb., Iran. J. Plant Path. 14:54,1978. 20068.
This species was described from Iran (Hallenberg, 1978), but in recent years also found in the Mediterranean area by Bernicchia.
As indicated in the original description, the thick-walled skeletal hyphae are morphologically different from those of Fibrodontia gossypina, and they do not occur in the aculei or in the smooth hymenium between the aculei. In most specimens they are easily distinguished as a very thin zone next to the substratum. Evidently the species does not belong in Fibrodontia but has similarities with Fibricium rude, especially in the nature of basidia and subhymenial hyphae. The fibre-hyphae also point to this genus.

Gloeocorticium cinerascens Hjortst. & Ryv. gen. nov. et spec. nov. Fig. 6. Fructificatio resupinata, effusa, mediocris crassa, hymenio plus minus sicco firmo ceraceo; systema hyphale monomiticum, hyphis plerumque distinctis, fibulatis; cystidia iterum atque iterum mamillata, perspicue amyloidea; basidia clavata, in typo circiter 20-25 x 6-7 µm, 4 sterigmatibus; sporis subglobosis, apiculo saepe laterale, inamyloidibus, indextrinoidibus, acyanophilis.

Type species: Gloeocorticium cinerascens Hjortst. & Ryv.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park., Cataratas de Iguazu. 1.-5. March 1982. L. Ryvarden No 19719 on Bamboo (O). Isotypus: (GB). Paratypi: 19600, 19612 (rather poor material), 19646, all on Bamboo.
Fruitbody resupinate, adnate, mostly thin, about 0.1-0.2 mm, continuous but minutely cracked, smooth, greyish-white; margin not specially differentiated. Hypal system monomitic, hyphae thin-walled, hyaline, smooth,

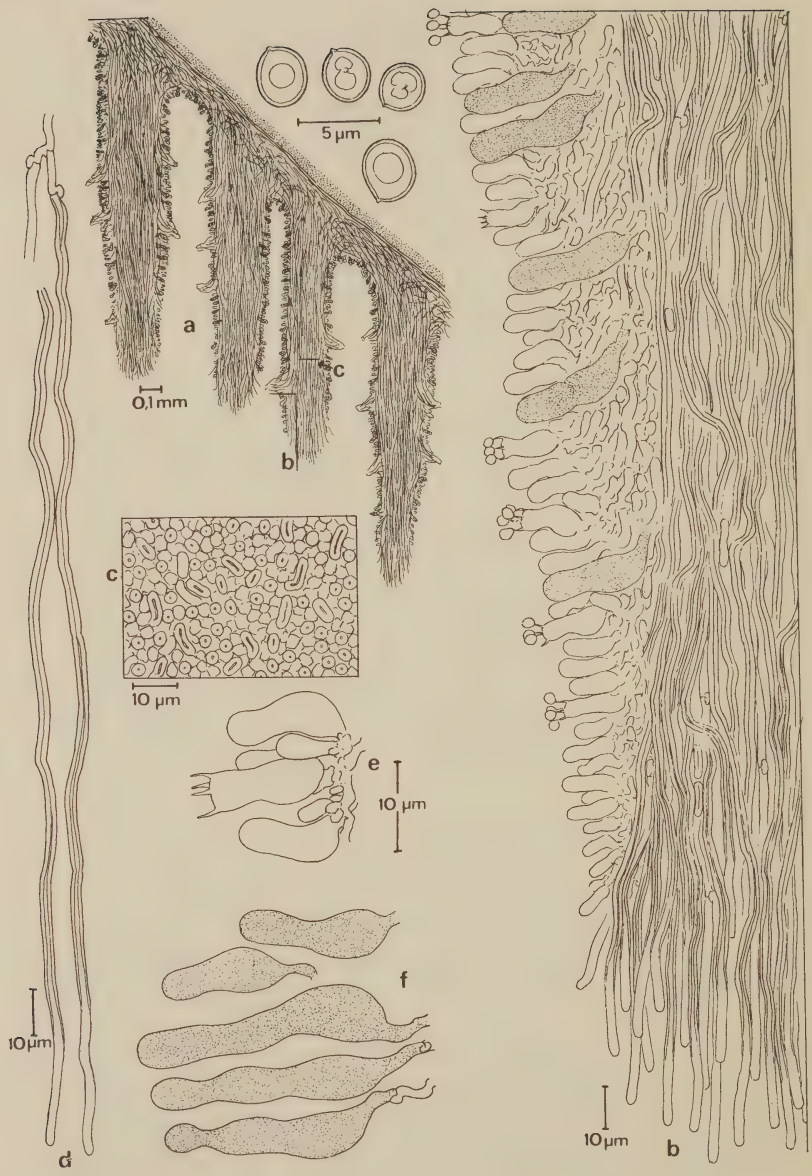

Fig. 6. **Gloeocorticium cinerascens** A) part of hymenium, B) cystidia, C) spores. From the holotype.

wall thickening, IKI- , generally 6.5-7 x 4.5-5 µm, apiculus distinct, placed laterally.
Remarks. This new genus and species has character similar to those of Radulomyces, especially the characteristic apiculus and to a certain degree also the basidia. However, the amyloid and moniliform gloeocystidia and the laterally depressed spores make the genus unique in the Corticiaceae s.l.

Gloeocystidiellum lactescens (Berk.) Boid. 19540, 19617, 19836.

Gloeocystidiellum triste Hjortst. & Ryv. spec. nov.
Fig. 7.
Fructificatio resupinata, arcte adnata, distincte stratosa, circiter 0.2-0.3 mm crassa, fere cornea; hymenio levi, pallide vel sordide brunneolo; systema hyphale monomiticum, hyphis tenuitunicatis vel crassiusculis, 2.5-3.5 µm latis, agglutinatis; hyphis subhymenialibus levibus, 2-2.5 µm latis, omnibus non-fibulatis; sulfocystidia tubularia, tenuitunicata vel basaliter crassiuscula, 100-150 (200) µm longa, 6-8(-12) µm lata; basidia clavata, 10-25(-30) x 3.5-5 µm, 4-sterigmatibus; sporis ellipsoidibus, subtiliter verrucosis, hyalinis, 5-6 x 3.5-4 µm, amyloidibus.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park., Cataratas de Iguazu. 1.-5. March 1982. L. Ryvarden No. 20055 (O). Isotypus: (GB).
Etymology: tristis = dull-coloured.
Fruitbody resupinate, tightly adnate, distinctly stratified and about 0.2-0.3 mm thick, consistency hard and somewhat horny, hymenium smooth, pale to sordidly brown; margin abrupt or slightly fibrillose. Hyphal system monomitic, basal hyphae thin-walled or with very slight wall thickening, hyaline, smooth, 2.5-3.5 µm wide, agglutinated in old tissues and with gelatinous interhyphal substance, subhymenial hyphae narrower, about 2 - 2.5 µm wide, hyaline, smooth, all hyphae without clamps. Gloeocystidia tubular, thin-walled or basally with thickened walls, sinuous, 100-150(-200) µm long and 6-8(-12) µm wide, often with several adventitious septa, in KOH with oily content and with a strong positive reaction in sulfuric benzaldehyde. Basidia clavate, loosely arranged, 20-25(-30) x 3.5-5 µm, with four sterigmata and without basal clamp. Spores ellipsoid, finely verrucose, hyaline, 5-6 x 3.5-4 µm, strongly amyloid.
Remarks. This species is easily recognized by its stratified fruitbody, clampless hyphae, and verrucose spores. It differs from other species with similar fructification and hyphae without clamps which are placed in Conferticium (e.g. C. karstenii (Bourd. & Galz.) Hallenb. and C. ochraceum (Fr.:Fr) Hallenb. by lacking the repetitive basidia. G. porosellum Hjortst., described from North Europe, is somewhat similar as to hyphae and

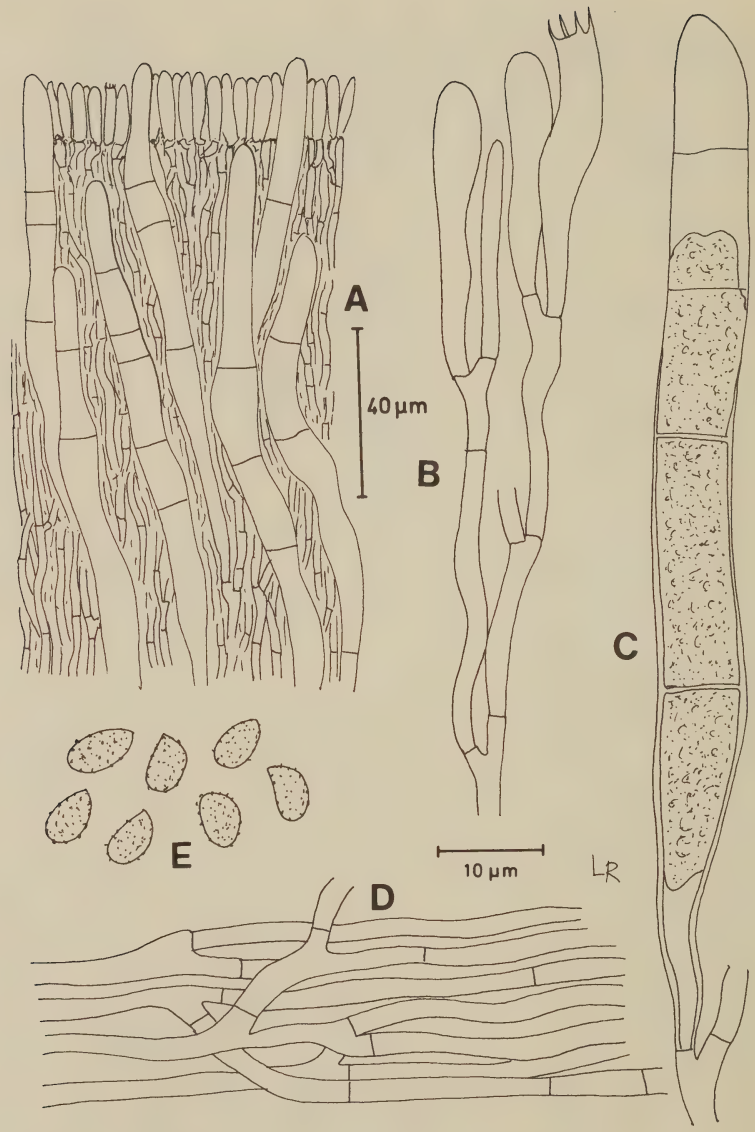

Fig. 7. **Gloeocystidiellum triste** A) section through hymenium, B) basidia, C) cystidium, D) hyphae from the subiculum, E) spores. From the holotype.

spores, but has thinner, not layered fruitbodies and is considerably softer. G. flammeum Boid. seems also to be closely related but lacks the blackish reaction in sulfuric benzaldehyde.

G. turpe Freeman 19773.
We agree with the author that this species should be placed in the vicinity of G. lactescens. However, the type of G. turpe has been examined and the Iguazu-specimen does not fully agree. The colour is more light-brown with the margin paler, and the tissue denser. The spores as well as the basidia and cystidia seem to conform to the description of G. turpe.

Hydrabasidium subviolaceum (Peck) John Erikss. & Ryv. 19741.

Hyphoderma argillaceum (Bres.) Donk 19788

Hyphoderma iguazuense Hjortst. & Ryv. spec. nov.
Fig. 8. Differt a Hyphodermate deviato cystidiis claviformibus et sporis leviter longioribus.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. park., Cataratas de Iguazu. 1.-5. March 1982. L. Ryvarden No 19576 (O). Isotypus: (GB). Paratypus: 19569 (O, GB).
Fruitbody resupinate, slightly adnate, pellicular to slightly membranaceous and more or less pliable, smooth or more commonly slightly pilose by protruding cystidia, in colour greyish white, margin indeterminable. Hyphal system monomitic; basal hyphae loosely interwoven, thin-walled to moderately thick-walled, as a rule encrusted with crystalline matter, 3.5-5.5 µm wide, sparsely ramified and in most cases branched from the clamps and forming a very thin tissue next to the substratum, subhymenial hyphae more densely united and vertically arranged, all hyphae with clamps, acyanophilous, indextrinoid. Cystidia cylindrical, subclavate or subcapitate, (30-)80-100 µm or sometimes considerably longer, thin-walled, apically widened to as much as 10-12 µm and 4-6 µm broad at the base, rarely with some adventitious septa, acyanophilous and seemingly without refractive content. Basidia more or less clavate, thin-walled, with an median constriction, (18-)20-25 x 4.5-5.5 µm, with four sterigmata and a basal clamp. Spores ellipsoid, smooth, thin-walled, (6-)6.5-8.5 x (3.2-)3.5-4 µm, with oily inclusions in the protoplasm, inamyloid, indextrinoid, acyanophilous.
Remarks. H. iguazuense is primarily separated from H. deviatum by wider and more pronounced clavate cystidia and somewhat longer spores. Further, the hymenium is whitish or cream-coloured, whereas in H. deviatum the normal colour is grey or whitish only towards the margin.

H. praetermissum (Karst.) John Erikss. & Strid 19844, 19858, 20051.

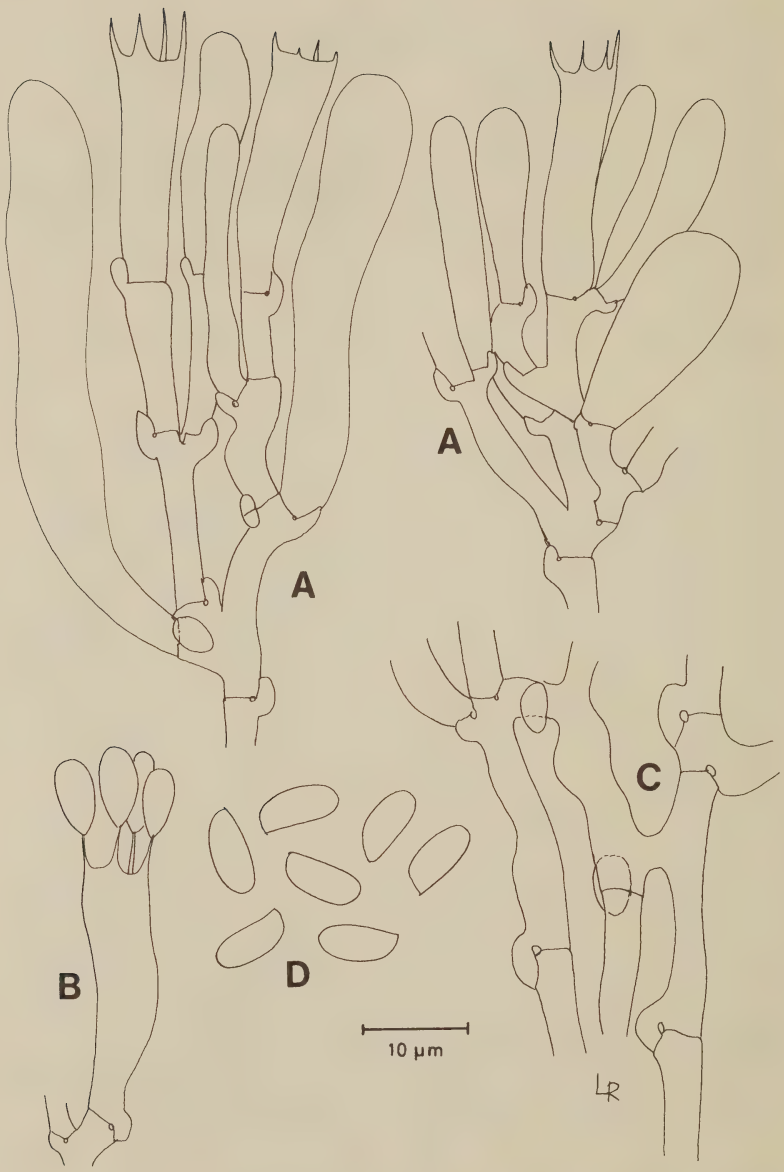

Fig. 8. **Hyphoderma iguazuense** A) part of hymenium with cystidia, B) basidium, C) hyphae from subiculum, D) spores. From the holotypes.

H. puberum (Fr.) Wallr. 19679.

H. rude (Bres.) Hjortst. & Ryv. 19771, 19773/B, 19806.
The specimens conform to the type but the stephanocysts are fewer.

H. setigerum (Fr.) Donk 19632, 20092.

Hyphodermella aff. corrugata (Fr.) John Erikss. & Ryv. 19509, 19825.
The specimens differ in having denser fructifications, smaller basidia and spores. H. corrugata was found several times in Rick's collections and previously reported from Brazil by Hjortstam and Ryvarden (1982).

Hyphodontia alutaria (Burt) John Erikss. 19532, 19614, 19823.

Hyphodontia apacheriensis (Gilbn. & Canf.) Hjortst. & Ryv. comb. nov.
Basionym: Poria apacheriensis Gilbn. & Canf., Mycologia 65(5):1117, 1973.
This species is strictly poroid but microscopically it conforms in essential characteristics with the genus Hyphodontia such as hyphae (especially the ramification) and basidia. The cystidia (or cystidioles) are very similar of those of H. aspera and H. breviseta. Compare also Poriodontia described by Parmasto (1982).
H. aff. brevidens (Pat.) Tyv. 19568, 19727, 19754, 19796, 20103.
This species is in many respects very similar to Fibrodontia gossypina Parm., e.g. outer appearance, hyphae, basidia, and spores. After having seen the type of Irpex brevidens it is with some doubt we accept the Iguazu-specimens as this species or as a species of its own. The type (see Ryvarden, 1983) of Irpex brevidens is surprisingly well preserved and microscopically easily studied but in time the colour of the hymenium has probably changed to a more brown tint. In the centre of the aculei there are many thick-walled hyphae or skeletals with fairly dense protoplasmatic contents. These hyphae contrast conspicuously with the other hyphae by their yellow colour. We consider I. brevidens not to be conspecific with F. gossypina.
The specimens from Iguazu are all similar but in comparison with the type of H. brevidens they differ in having hyaline central aculeal hyphae with thinner walls. Such hyphae are often seen in many odontioid species of Hyphodontia though with slightly wider lumen and they are not treated as skeletals by most corticiologists.
Further studies of this taxon (or taxa) in South America is needed and additional specimens will be highly appreciated.

H. sambuci (Pers.) John Erikss. 19785.

H. aff. knysnana (van der Byl) Reid 19606, 20054. Originally this species was described from South Africa and re-collected by Ryvarden in Tanzania (No. 10126, O). The Iguazu specimen corresponds well with the isotype (at Kew) as well with the Tanzanian collection but seems to have somewhat narrower spores. H. knysnana belongs in the subsection Ellipsosporae Parm. and its closest relative is H. nudiseta Warc. & Talb.

Hyphodontia lutescens Hjortst. & Ryv. spec. nov. Fig. 9. Ex affinatate Hyphodontia aspera et H. breviseta ab utroque cystidiis flexuosis, obtusis, neque capitatis, sporis ellipsoidibus, generaliter 6.5-7 x 3.5-3.8 µm. Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park., Cataratas de Iguazu. 1.-5. March 1982. L. Ryvarden No. 19758 (O). Isotypus: (GB).

Fruitbody resupinate, closely adnate, fairly tough but easily squashed under a cover-glass, creamish to pale yellowish, hymenium odontioid, with small, conical aculei, approximately 2-4 per mm, smooth or apically fimbriate by protruding hyphae or cystidial elements, hymenium between the aculei smooth, fairly firm; margin thinning out or slightly fibrillose. Hyphal system monomitic, hyphae hyaline, thin-walled or with slight wall thickening, smooth or slightly encrusted, 3-4 µm wide, straight in the centre of the aculei, irregularly interwoven in the subicular tissue, walls acyanophilous, all hyphae with clamps. Cystidial elements more or less hyphoid and little differentiated from hyphae and basidia, warying in size and appearance, usually flexuose, 30-50 µm long and 3-4 µm wide, mostly observed in the aculei but also frequently occurring in the smooth hymenium between the aculei. Basidia subclavate, after sporulation elogated, more or less urniform, thin-walled, 18-20(-30) x 4-4.5(-5) µm, with four sterigmata and a basal clamp. Spores ellipsoid, smooth, thin-walled, (6-)6.5-7(-7.5) x (3-)3.5-3.8 µm, with one or few oildrops in the protoplasm.
Remarks. Externally H. lutescens resembles of H. aspera but this species is ordinarily whitish and under a microscope immediately separated by more subglobose spores and capitate cystidial elements.

Hyphodontia tenuicystidia Hjortst. & Ryv. spec. nov. Fig. 9.
Fructificatio resupinata, adnata, circiter 0.1-0.2 mm crassa, pallide ochracea; hymenio levi vel parum tuberculato; systema hypahle monomiticum; subiculum indistinctum, hyphis paucis, parallele, tenuitunicatis, 2.5-3 µm latis, fibulatis; hyphis subhymenialibus plus minus verticalibus, densis, 2-4 µm latis, itidem fibulatis; cystidia sparsa, tubuliformia, tenuitunicata, hyalina, 90-100 x 4-6 µm, obtusa; basidia primum subclavata tum suburniformia, basaliter crassiuscula, 20-25 x 3-4 µm, 4-sterigmatibus; sporis ellipsoidibus,

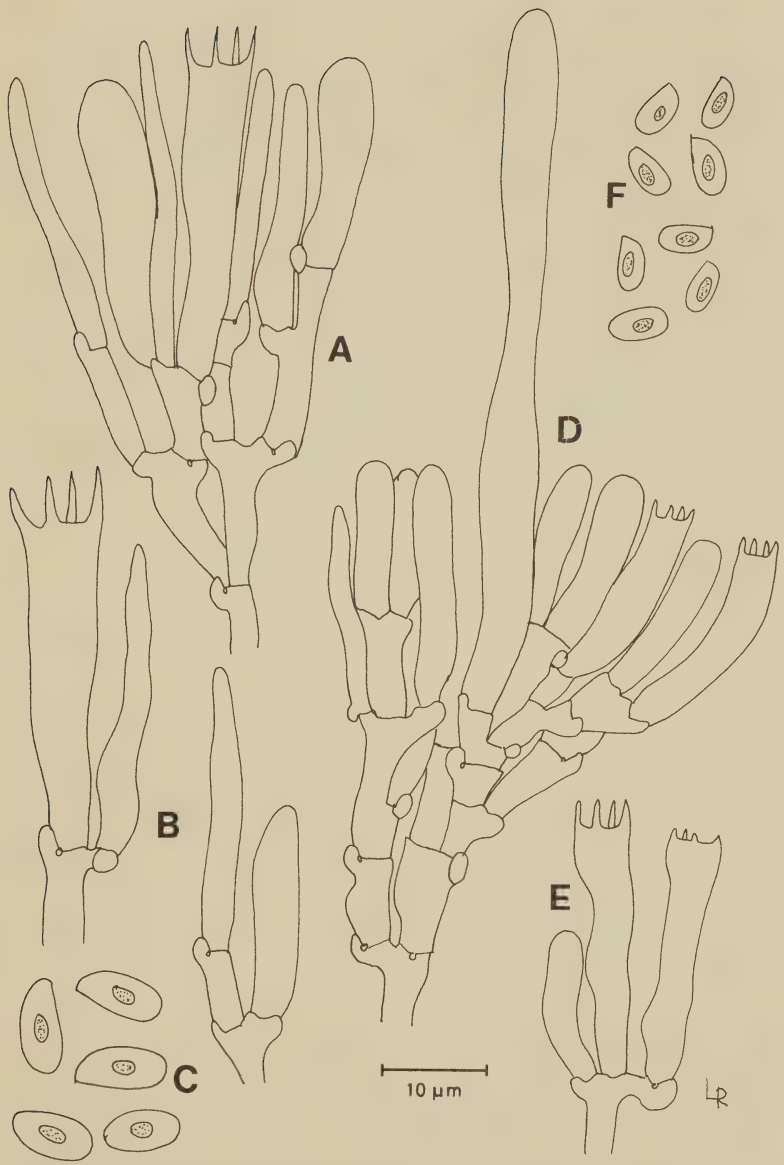

Fig. 9. **Hyphoderma lutescens** A) part of hymenium, B) basidium, C) spores. - **Hyphodontia tenuicystidia** D) hymenium with cystidium, E) basidia, F) spores. From the holotype.

levibus, tenuitunicatis, 5-5.5(-6) x 2.8-3.2 µm.

Fruitbody resupinate, closely adnate, not separable from the substratum, thin, approximately 0.1-0.2 mm, pale ochraceous; hymenium smooth or very slightly tuberculate, cystidia emergent as glittering drops; margin indeterminable. Hyphal system monomitic; subiculum lacking or mostly indistinct with few parallel hyphae next to the substratum, thin-walled, 2.5-3 µm wide, hyaline, subhymenial hyphae intermingled, arranged vertically in a fairly dense tissue, short-celled, about 2-4(-5) µm wide, all hyphae with clamps Cystidia well differentiated, scattered, tubular and as a rule widened at the base, protrude above the basidia as much as 30-50 µm, thin-walled, acyanophilous, hyaline but with oily contents visible in cotton blue, 90-100 µm long and 4-6 µm wide, apically narrowing slightly to the obtuse tip. Basidia at first subclavate then suburniform and typically with a median constriction, with thickened basal walls and lightly cyanophilous, 20-25 x 3-4 µm, with four sterigmata and a basal clamp. Spores short-ellipsoid, adaxially slightly concave, smooth, thin-walled, 5-5.5(-6) x 2.8-3.2 µm.

Remarks The shape of the basidia and hyphae of this species are similar to that of H. pallidula and H. alutaria but it differs primarily by its long and thin-walled cystidia which makes the species easy to recognize. The position in the genus seems to be fairly isolated.

Hyphodontia wrightii Hjortst. & Ryv. spec. nov. Fig. 10.
Fructificatio resupinata, adnata, cremea vel pallide ochracea; hymenio dense granulato, aculeis 6-10 per mm, conicis vel semiglobosis, levibus vel leviter fimbriatis; systema hyphale monomiticum; hyphis tenuitunicatis, 2.5-3 µm latis, hyalinis, modice cyanophilis, fibulatis; cystidia conspicua, numerosa, ad apicem incrustata, 30-50 µm longa; basidia suburniformia, tenuitunicata, a medio ad apicem crassiuscula; sporis anguste elliosoidibus, levibus, tenuitunicatis, 5-5.5 x 2.5-3 µm.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park., Cataratas de Iguazu. 1.-5. March 1982. L. Ryvarden No. 19636 (O). Isotypus: (GB).
Etymology: in honour of prof. Jorge E. Wright.

Fruitbody resupinate, closely adnate, fairly dense but soft in consistency, creamish to very pale ochraceous; hymenium densily granular with small warts, 6-10 per mm, conical or more commonly semiglobose, smooth or apically slightly fimbriate because of protruding hyphae and cystidia; margin indeterminable. Hyphal system monomitic; subiculum very thin to inconspicuous with few parallel hyphae, thin-walled, 2.5-3 µm wide, hyaline, subhymenial hyphae vertically arranged in a fairly dense and thin

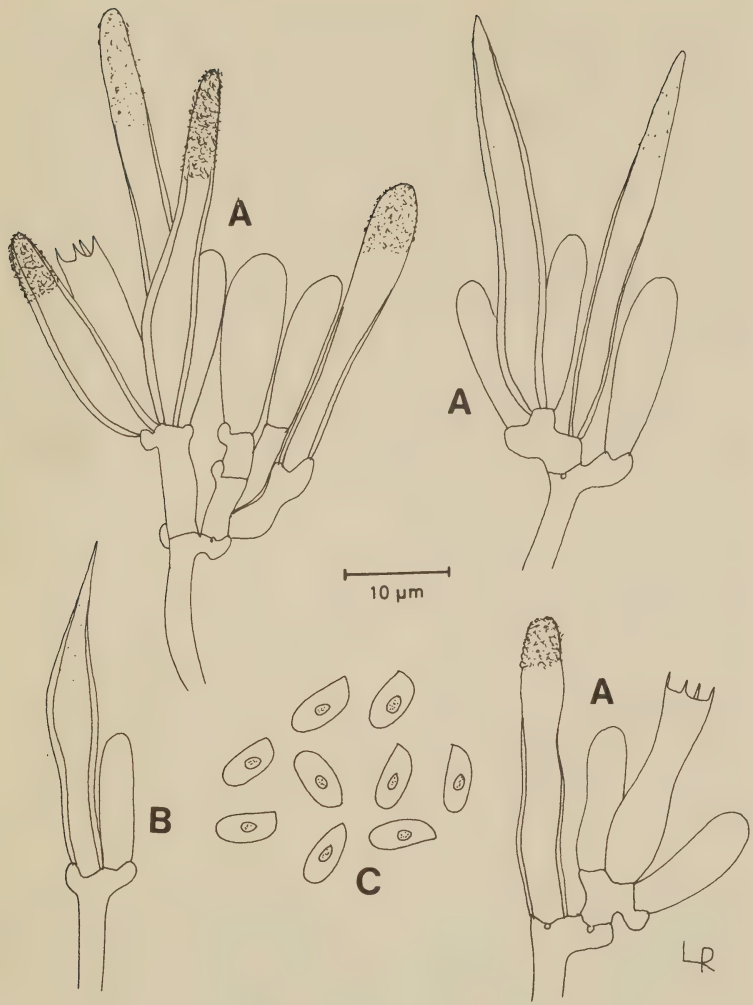

Fig. 10. **Hyphodontia wrightii** A) clusters of basidia and cystidia, B) acute cystidium, C) spores. From the holotype.

tissue, all hyphae with a slight to a more strong cyanophilous reaction, with clamps at every septa. Cystidia conspicuous, in the aculei especially numerous, easily observed thanks to the strongly encrusted tip, 30-50 µm long thin-walled or with slight wall tickening, in age more or less distinctly thick-walled. Basidia at first subclavate then suburniform, with a median constriction, thin-walled except in the basal part which tends to be rather thick after sporulation, walls weakly cyanophilous, 15-20 x 3.5-4 µm, with four slender sterigmata about 3-4 µm long, and a basal clamp. Spores narrowly ellipsoid, smooth, thin-walled, 5-5.5 x 2.5-3 µm.
Remarks. H. wrightii is superficially similar to species in the sectio Hyphodontia (e.g. H. alutaria and H. pallidula) by its encrusted cystidia. It is questionable, however, if H. wrightii belongs with the above species as its cystidia differ from true lagenocystidia. The walls are thin to moderately thick, whereas in the cystidia of H. alutaria the walls are distinctly thick, especially at the pointed apex. Macroscopically as well as in the morphology of basidia and hyphae it resembles H. rimosissima (subsectio Ellipsosporae Parm.) more closely.

Hypochnella violacea (Auersw.) Schröt. 19583.

Hypochnicium rickii Hjortst. & Ryv. 20090.
This specimen agrees with the type (Rick, 20847) except in its outer appearance. The aculei are more scattered, (3-6 per mm) and the whole fungus somewhat tough. The species is only known from these two specimens.

Odonticium helgae Hjortst. & Ryv. spec. nov. Fig. 11.
Differt ab Odonticio laxo hyphis basalibus hyalinis, tenuitunicatis. vero incrustatis.
Holotypus: Argentina. Prov. Misiones, Iguazu Nat. Park., Cataratas de Iguazu, 1.-5. March, 1982. L. Ryvarden No. 20082 (O). Isotypus: in Hjortst. priv. herb.
Etymology: in honour of Dr. Helga Grosse- Brauckmann.

Fruitbody resupinate, loosely adnate, pellicular and fairly soft, whitish to pale ochraceous; hymenium distinctly odontioid with the aculei approximately 4-6 per mm, usually fimbriate apically, subiculum concolorous or very pale ochraceous, thin, rhizomorphs abundant, especially in the periphery of the fruitbody. Hyphal system monomitic; hyphae without clamps, basal hyphae straight and fairly uniform, thin-walled or with slightly thickened walls, branching at right angles, strongly encrusted, 3-5 µm wide with the individual cells about 30-50 µm long between the septa, aculeal hyphae thin-walled, more or less smooth, some protrude as much as 20-30 µm, 4-5 µm wide. Cystidia absent. Basidia small, 8-12 x 4-5 µm, somewhat clustered, with 4 sterigmata. Spores subglobose to ellipsoid, smooth, thin-walled, 3-3.5 x 2-3.2 µm, inamyloid, indextrinoid, acyanophilous, often with a central oildrop.

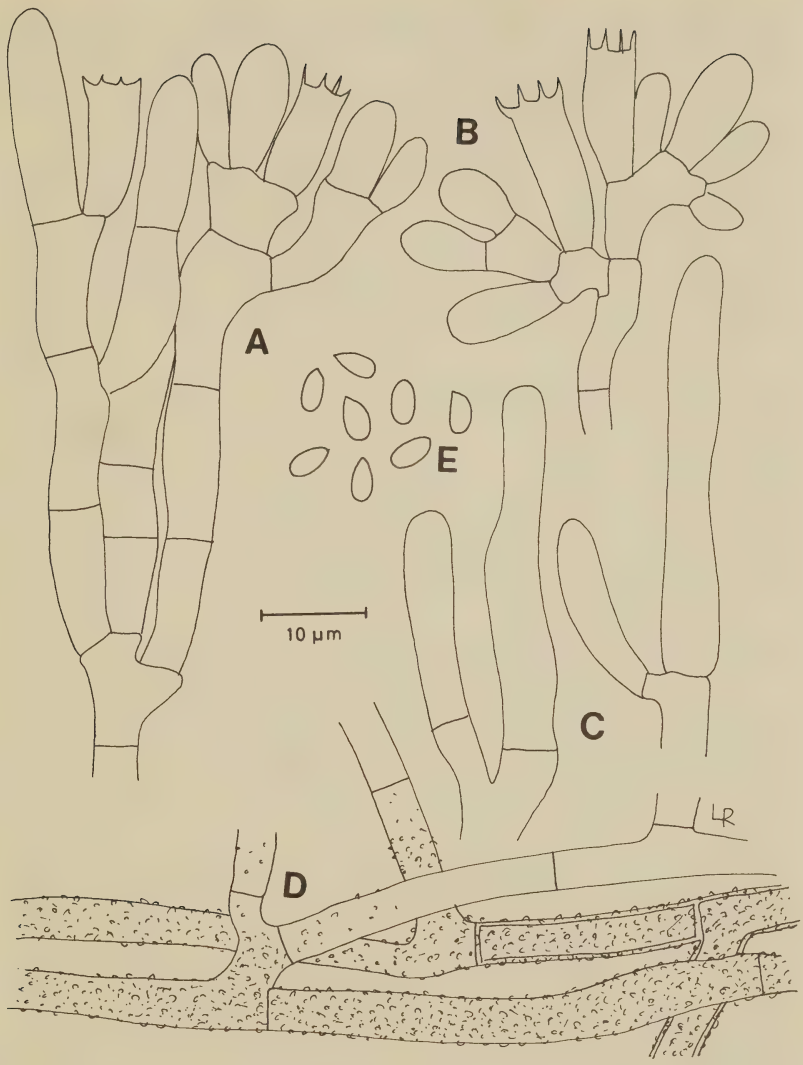

Fig. 11. **Odonticium helgae** A) part of hymenium, B) basidia, C) aculeal hyphae, D) encrusted basal hyphae, E) spores. From the holotype.

Remarks. Macroscopically Odonticium helgae is similar to O. laxum and it has the same kind of rhizomorphs, running over the substratum and easily observed under a strong lens. Microscopically the two species are easily separated. The former has more or less hyaline and thin-walled hyphae, as a rule strongly encrusted with crystalline matter, while in the latter the hyphae are distinctly yellowish, moderately thin-walled and smooth or less encrusted. Further, the conspicuous and encrusted hyphoid elements that occur abundantly in the apical part of the aculei in O. laxum, are absent in O. helgae.
This species was first collected in Germany by Grosse-Brauckmann, Larsson, and Hjortstam (Hessen, Oberrhein, Kühkopf, Dornschlag, on Fraxinus. 1983-10-17. In herb. GB and Grosse-Brauckmann priv. herb.) and surprisingly it was found again in Iguazu.

O. laxum (Miller) Ryv. 19563.
It should be noted that an holotype specimen, on elm, July 30, 1893, was indicated by Miller in the original description (1934) and consequently the Iowa specimen, Wellman, on old bark of deciduous wood, L.W. Miller No. 338. Oct. 8, 1932 is a paratype (compare Gilbertson, 1964). The latter specimen has not been studied by us. Both the original specimens are at IA. There are good descriptions by Miller (1934) and Gilbertson (1964) and an instructive figure by John Eriksson in Ryvarden (1978).

Odontiopsis hyphodontina Hjortst. & Ryv. 19559, 19847, 19859, 19864. This species is characterized by its strongly encrusted and projecting aculeal hyphae, relatively short basidia (approximately 12-15 µm), and globose to subglobose spores that are 4-5 µm in diam. Originally the genus was based on a single African specimen (Hjortst. & Ryv., 1980) and the Iguazu-collections are similar to the type but are younger and softer with less crowded aculei.

Radulomyces confluens (Fr.:Fr.) M.P. Christ. 19514, 20094. Specimen 19514 is best developed and is in all characteristics, except spores, which are subglobose, exactly like specimens from different parts of boreal and other areas. Corticium rickii Bres (in Rick, 1898) is based on a specimen of this type collected in Austria. M.P. Christiansen (1960) introduced the name in North Europe but Eriksson et al. (1981) were of the opinion that it possible only represents one extreme spore-form of R. confluens.
We have studied an original specimen of the species and are convinced that it is Thelephora confluens and herewith placed in synonymy with this species.
Lectotypus of Corticium rickii Bres.: (designated here) ad truncos Sambuci nigrae. Feldkirch. Oct. 1879, leg. J. Rick (FH).

Scopuloides rimosa (Cooke) Jülich 19531.
This specimen is in fully accordance with the type of Peniophora rimosa described from Colwyn Bay (Wales) and deposited at Kew. It should be noted that the same species has been found once in Western Germany (Hjm 14174, GB). See also Eriksson et al. (1984).

Scytinostroma aff. albo-cinctum (Berk. & Br.) Boid. & Lanq. 19740, 20049.
These collections agree well with the description and figure in Boidin and Lanquetin (1976), but we have not seen any authentic material of the species. The chatacteristic skeletohyphidia (see Parmasto, 1970), react strongly in Melzer and the ultimate branches are bent outwards. However, it should be mentioned that Boidin kindly determined the specimens, but later he changed his opinion and thought it could be an independent species. See also S. portentosum.

S. ochroleucum (Bres. & Torr.) Donk 19509/B.

S. portentosum (Berk. & Curt.) Donk 19558, 19561, 19573, 19604, 19610,19622, 19675, 19764, 19792, 19818, 19855, 20046.
The holotypes of Corticium portentosum Berk. & Curt. (Pennsylvania, Michener No. 3620) and of Stereum duriusculum Berk. & Br. (Ceylon, Kandy 1868. No. 329 & 569, apparently from same specimen) have carefully been studied and we are not convinced that the two species may be separated on the basis of macro- and micro-morphology. A separating characteristic (according to Parmasto, 1970, and others) should be the numbers of gloeocystidia. The type of S. duriusculum has some cystidia but the material is too poor for a adequate examination. Besides, a few cystidia are also present in the type of S. portentosum, which also is a rather poor material. Other characteristics such as spores and hyphae (strongly dextrinoid) can readily be studied in both specimens, but cannot be used to separate the two species.
Thus, we adopt the oldest name for the Iguazu-material. All specimens reported here have gloeocystidia in varying numbers, and some react positively in sulfuric benzaldehyde. S. albo-cinctum can be distinguished from S. portentosum by its somewhat darker hymenium and microscopically the skeletohyphidia seem to be an important separating character.

Sistotrema brinkmannii (Bres.) John Erikss. 19787.

Subulicystidium longisporum (Pat.) Parm. Very common, and 15 specimens collected in Iguazu. The species is highly variable, especially in its spore-length but also in size and encrustations of the basidia-bases and hyphae.

Trechispora farinacea (Per.:Fr.) Liberta s. lato 19537, 19631.

T. regularis (Murr.) Liberta 19570, 19575, 20108/B
Tubulicium vermiferum (Bourd.) Oberw. ex Jülich 19728.
The spores of this specimen are about 15-20 x 2.5-3 µm, less worm-shaped than normal but still with sigmoid appearance.

Vararia rugosispora Boid. et al. 19706.
The brownish fructification, hyphae without clamps, and the large spores (approximately 12-15 x 6-8 µm which are distinctly rough (properly observed in Melzer) make this species easily to recognize. Previously known only from the type-locality (Gabon, Africa). For adequate description, see Boidin & al. (1980).

V. sphaericospora Gilbn. 19528.
This specimen has been compared with the holotype (BPI) and corresponds in essential characteristics. Cystidia, however, have not been observed. A portion of Ryvarden's collection is deposited in BPI. Recently the species has also been reported from Africa and Asia (Boidin & Lanquetin, 1984).

Xenasma praeteritum (Jacks.) Donk 19522, 19695 (see below).
The first specimen is so close to Jackson's description (1950) and to the five specimens listed from the type-locality (Ontario, Frontenac) that we do not hesitate to treat our collections under this name. The other specimen is more problematic. It has larger spores and cystidia with thicker walls and it reminds of X. rimicolum (Karst.) Donk, but the material is too scarce to permit a more precise interpretation. We have, in an article from Nepal, dealt with two specimens that clearly differ from the original scope of X. praeteritum (odontioid species) and we have seen material from Africa which fits neither Jackson's species nor the Nepal collections or X. rimicolum. The genus will be treated separately in a forthcomming paper and in the Corticiaceae of North Europe (Vol. 8).

X. pruinosum (Pat.) Donk 19730.
Most basidia evidently have more than 4 sterigmata and the spores are echinulate (only visible in Melzer and Cotton-blue) and measure ab. 7-8 x 4-4.5 µm.

Acknowledgments.

Dr. J. Wright of the Buenos Aires is most sincerely thanked for his generous help and assistance in arranging the excursion to the Iguazu National Park, making this paper possible. Dr. E. Parmasto of Tartu, Estonian SSR, USSR, and Dr. R.L. Gilbertson, University of Arizona, Tucson, Arizona, United States, have both suggested improvements in the text for which we are grateful.

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MYCOTAXON

Vol. XXV, No. 2, pp. 569-580 April-June 1986

LASIOSPHAERIOPSIS STEREOCAULICOLA

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ABSTRACT

Sphaeria stereocaulicola Lindsay (syn. **Xenosphaeria apocalypta** Arnold) is transferred to **Lasiosphaeriopsis** D. Hawksw. & Sivanesan (Nitschkiaceae). The spores are shown to possess a few scattered pores.

INTRODUCTION

Ascomycetes characterized by perithecioid ascomata, thick-walled asci, pseudoparaphyses and coloured ascospores with two or more transsepta have usually been referred to the genus **Leptosphaeria** Ces. & De Not. Similar fungi with spores also divided by longisepta have been classified in the genus **Pleospora** Rabenh. ex Ces. & De Not. Both genera have grown very large and become heterogeneous. In current classifications some workers accept these large genera for practical purposes, others prefer to split them and recognize several more homogeneous segregate genera. With narrower generic concepts, however, there are still many foreign elements in the two genera with uncertain affinities. One of us (RS) has for a long time been aware of that the lichenicolous species **Leptosphaeria apocalypta** (Arnold) Winter has to be transferred to another genus. We have examined material of this species in detail and found that it belongs to the previously monotypic genus **Lasiosphaeriopsis** D. Hawksw. & Sivan., and that the oldest name for the species is **Sphaeria stereocaulicola** Lindsay.

MATERIALS AND METHODS

Ascomata of the species studied in this paper were embedded in Historesin, and semithin sections were made on a Historange microtome (see Yue & Eriksson 1985: 293). SEM graphs were produced with a JEOL JSM-P15.

RESULTS

Lasiosphaeriopsis stereocaulicola (Lindsay) O. Eriksson & R. Santesson comb. nov.

Basionym: (**Sphaeria sp.** Th. M. Fries, Kongl. Svenska Vet.-Akad. Handl. 7, n. 2: 36, footnote, 1867) - **Sphaeria stereocaulicola** Lindsay in Trans. R. Soc. Edinburgh 25 (2): 528 + 538 (1869). - Orig. coll.: Spitzbergen, West-Spitzbergen, Hinlopenstredet, Lovénfjellet, 1861 A.J. Malmgren. On **Stereocaulon alpinum** (thallus), (holotype, UPS).

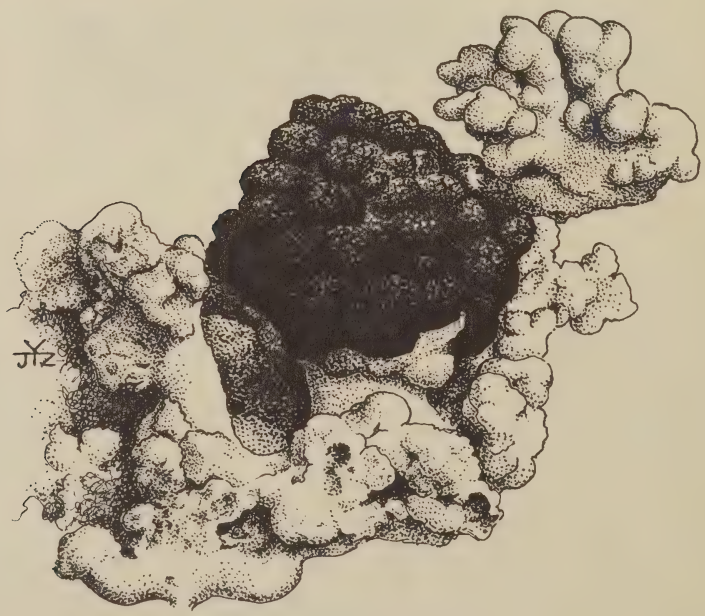

Fig. 1 **Lasiosphaeriopsis stereocaulicola,** ascomata on thallus of **Stereocaulon alpinum.** Coll.: Torne Lappmark, 1947 R. Santesson. Magn.: X25.

Synonyms: **Xenosphaeria apocalypta** Rehm (Ascom. exs. n. 346, 1876, nom. nud.) ex Arnold, Flora 60: 302 (1877). - **Leptosphaeria apocalypta** (Rehm ex Arnold) Winter, Rabenh. Krypt.-Fl., 1(2): 442 (1885). - **Arthopyrenia apocalypta** (Rehm ex Arnold) Olivier, Bull. Acad. Geogr. Bot. 16: 262 (1906). - Orig. coll.: Austria, Tirol, Ober-Inntal, Piztal, Mittagskögele bei Mittelberg, 1875 F. Arnold (Rehm, Ascom. exs. 346). On **Stereocaulon alpinum** (thallus), (isolectotypes, S, UPS.)

Figs.: 1-3, 5.

Fig. 2. **Lasiosphaeriopsis stereocaulicola**, submedian section through ostiole with periphyses. Coll.: Torne Lappmark, 1947 R. Santesson. Magn.: c. X500.

Ascomata perithecioid, rarely solitary, more often densely aggregated into moriform clusters on hypostromata, erumpent and finally ± free, subglobose, without neck, sessile, tuberculate with deep fissures, carbonaceous, black. Ascomal wall c. 50-70 µm thick, outermost part of dark-coloured, thick-walled pseudoparenchymatous cells with distinct "Munk pores", inner parts with gradually paler and thinner-walled cells. Uppermost part of locule with very large, thin-walled cells, producing periphysoids directed downwards and periphyses directed upwards; ostiolar channel c. 30-40 µm wide, lined by smaller cells producing numerous periphyses (Fig. 2), some of which at the mouth have dark-coloured, rounded tips.

Asci c. 90-100 x 12-14 µm, unitunicate, subcylindrical, short-stalked, thin-walled (especially at the rounded apex, Fig. 3A), without apical ring, I- (not I+ as given by Keissler 1930: 498), 4-spored.

Ascospores (Fig. 3B-F) c. 30-35 (-53) x 10-11 (-13) µm, broadly fusiform, with (2-)4-5(-9) transverse (or often also some oblique) septa with ± distinct central pore, dark brown, without distinct perispore, wall thin, smooth, in each segment with one very small pore (Fig. 5); each segment with one large and numerous small drops. Immature spores at first non-septate, then 2- (3-)septate, hyaline with c. 2.5-3 µm thick, non-stratified, hyaline wall (Fig. 3B, C). Each segment then divided by a transseptum and wall becoming 3-layered and pale brown (Fig. 3D).

Hosts: **Stereocaulon alpinum**, **S. glareosum**, **S. humbertii**, **S. paschale**, and **S. rivulorum**.

Material examined:

A R G E N T I N A, Patagonia, Prov. Chubut, Lago Menendez, on **S. paschale**, 1950 I.M. Lamb n. 5780 (UPS).

A U S T R I A. See above, the type of **Xenosphaeria apocalypta**.

S W E D E N, Härjedalen, Tännäs par., Grönvålen, alt. 1050 m., on **S. glareosum**, 1974 R. Santesson n. 25078b (M, S, UPS, US, etc.; will be distributed in R. Santesson, Fungi Lichenicoli Exs., Fasc. V), Fjällnäs, Gråstöten, on **S. sp.**, 1912 E.P. Vrang (UPS), Stora Mittåkläppen, SW. slope, alt. c. 1100 m., on **S. alpinum**, 1976 R. Santesson n. 27029b (UPS); Jämtland, Åre par., Åreskutan, Lillskutan, alt. 810 m., on **S. rivulorum**, 1948 R. Santesson n. 48579 (UPS), Åreskutan, Totthummeln, alt. 825 m., 1948 R. Santesson n. 48560 (UPS); Torne Lappmark, the Torneträsk area, Vassitjåkko, NE. slope, alt. 870 m., on **S.**

alpinum, 1947, R. Santesson (UPS),Abisko, on the railway cutting SW. of the Research Station, alt. 380 m., on **S. rivulorum**, 1959 R. Santesson n. 13404c (UPS). Karesuando par., Peldsa, the SE-top, alt. 850-1000 m., on **S. rivulorum**, 1948 T. Hasselrot (UPS).

S P I T Z B E R G E N. See above, the type of **Sphaeria stereocaulicola** Lindsay.

U G A N D A, Mt. Ruwenzori, Mijusi Valley, E. slope of Mt. Speke, alt. 4480 m., on **S. humbertii**, 1948 O. Hedberg n. 561b (UPS).

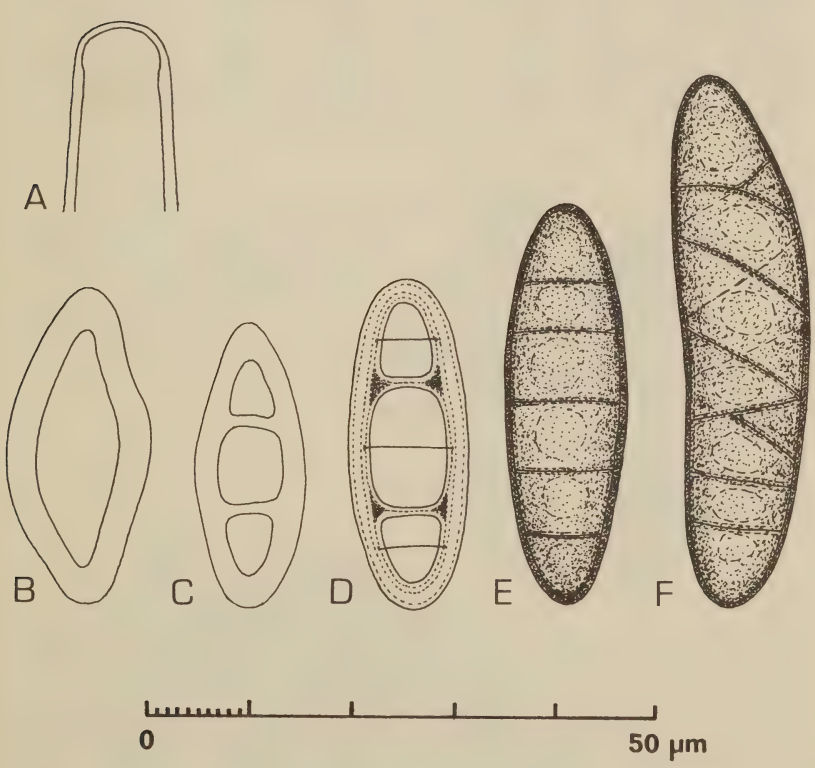

Fig. 3. **Lasiosphaeriopsis stereocaulicola.** (A) Ascus top. (B-D) Immature spores. (E) Mature, dark brown spore. (F) Abnormal spore with transsepta, oblique septa and helicoid septa. Coll.: Torne Lappmark, 1947 R. Santesson.

DISCUSSION

As mentioned above, two different epithets have been used for the characteristic fungus on **Stereocaulon spp.** treated in this paper, viz. "stereocaulicola" (Lindsay 1869: 528, 538) and "apocalypta" (Rehm 1876).

Lindsay (p. 528) referred to the fungus as "**Sphaeria (Stereocaulicola)**, Th. Fries" and (p. 538) wrote "Th. Fries* has described, without naming, a **Sphaeria** as parasitic on the thallus of **S. alpinum**, Laur., in Spitzbergen; whose sporidia, however, distinguish it from the **Microthelia**. The hymenium of the **Sphaeria** - which may appropriately bear the specific name **Stereocaulicola** - becomes yellow with iodine. The sporidia are blackish, four in each ascus, oblong-elongate, 3-5-septate, becoming submuriform by longitudinal division of the loculi" (* "Lichenes Spitsbergensis", p. 36). We regard these two passages in

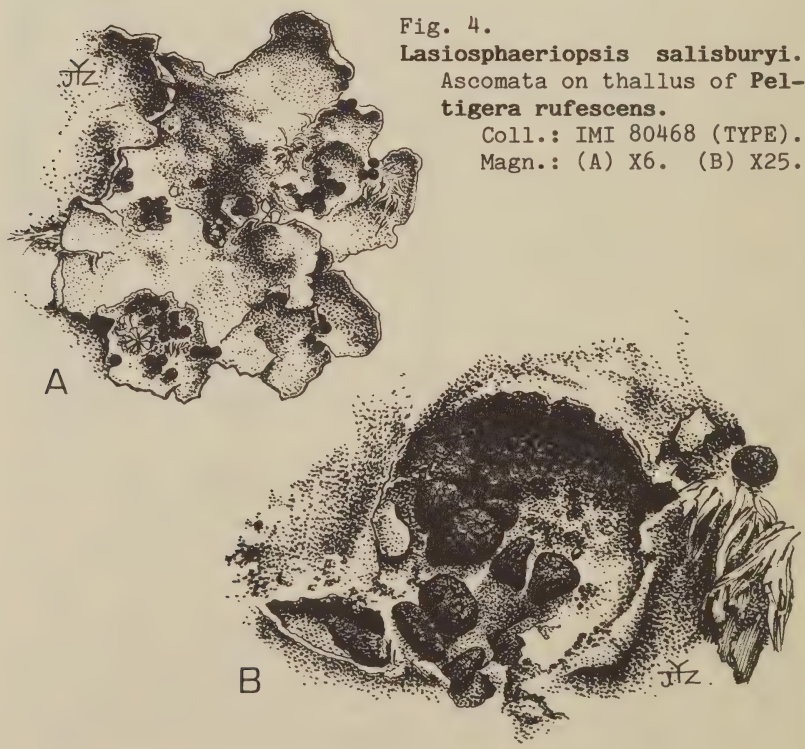

Fig. 4.
Lasiosphaeriopsis salisburyi. Ascomata on thallus of **Peltigera rufescens.**
Coll.: IMI 80468 (TYPE).
Magn.: (A) X6. (B) X25.

Lindsay (1869) as a valid description of **Sphaeria stereocaulicola** Lindsay.

Rehm distributed without any description in his exsiccatum Ascomyceten n. 346 (1876) a lichenicolous fungus named **Xenosphaeria apocalypta**. In the following year Arnold (1877a: 302, published July 1) described the species. A description was given also in Arnold 1877b: 547 ("Vorlegt in der Versammlung am 4. Juli 1877"). Arnold refers in the original description to two different collections. The one distributed in Rehm's exsiccatum is here chosen as lectotype. It was transferred to **Leptosphaeria** by Winter (1885: 442), but he pointed out that it is very doubtful whether this and some other lichenicolous species really belong to **Leptosphaeria**. Squash mounts and semi-thin sections of ascomata show that this fungus is a member of **Lasiosphaeriopsis** D. Hawksworth & Sivanesan (in Hawksworth 1980: 373), which currently is classified in the Nitschkiaceae. Its correct name is **L. stereocaulicola** (Lindsay) O. Eriksson & R. Santesson.

Lasiosphaeriopsis was described to accomodate a new lichenicolous pyrenomycete on **Peltigera rufescens, L. salisburyi** D. Hawksw. & Sivan. We have studied a part of the type material (England, Lancashire, Ainsdale, Hillside Sandhills, 23.III.1951, G. Salisbury 124, IMI 80468), and can confirm the observations made by Hawksworth & Sivanesan. The ascomata are laid down in the algal layer of the host and seem to cause local destruction of the cortex. Most of the ascomata are seen either at the margins and cracks of the thallus or in small whitish pits with naked medulla (Fig. 4B). The coarsely verrucose ascomata are often provided with a short stalk, which is usually somewhat compressed.

The ascomata of **L. stereocaulicola** are similar to those of the type species, but are more often densely aggregated into moriform structures (Fig. 1) and are not seated on a compressed stalk. In both species the walls of the ascomata are dissected by deep fissures. The walls are thick and consist of many layers of cells; the outermost are dark brown and have distinct "Munk pores", the inner are paler , with thinner walls. The hamathecium consists of short periphysoids directed downwards and periphyses in the ostiolar channel directed upwards. Asci are thin-walled and produce dark brown phragmospores. While the spores are of about the same sizes in the two species, the septation is different. The spores are 3(-4)-septate in **L. salisburyi**, (2-)5(-9)-septate in **L. stereocaulicola**.

We have examined the spores of both species with light and scanning electron microscopy. In **L. salisburyi** the spore wall is absolutely smooth, while in **L. stereocaulicola** we have observed some very small pores in the wall (Fig. 5). There appears never to be more than one pore in each segment. These pores may be very difficult to see using light microscopy. However, they are more easily seen

Fig. 5.
Lasiosphaeriopsis sterocaulicola, ascospore with pores (arrows).
Coll.: Torne Lappmark, 1947 R. Santesson.
Magn.: c X3700.

Fig. 6.
Lasiosphaeriopsis salisburyi, ascospore without pores.
Coll.: IMI 80468 (TYPE).
Magn.: c. X2600.

in fragments of spore wall not obstructed by other structures. We have not seen any germinating spores, but it is probable that the spores germinate by phialide-like germ tubes through these pores. Such phialides have been observed in the genera **Bertia** De Not. (Sivanesan 1978: 385, 387;Corlett & Krug 1984: Fig. 3D, 2566) and **Lasiosphaeriella** Sivanesan (1975: Figs. 1C and 2C).

Keissler (1930: 498) wrote about **L. stereocaulicola** (as **Leptosphaeria apocalypta**) "Auffallend erscheint die Angabe, dass die Gehäuse mit Falten und zahlreichen Spalten sich öffnen. Die Sache verdiente überprüft zu werden". The ascomata do not open in this way. They open by an ostiole lined with hyaline periphyses. Some of the periphyses at the mouth are dark-coloured in their upper halves. We found that such, almost bristle-like periphyses were also present in **Bertia moriformis** (Tode: Fr.) De Not. They seem to have been overlooked by previous authors. Nannfeldt (1975: 294) referred to the dark tissue in the opening as a plug, but is better described as densely packed, melanized periphyses tips.

Nannfeldt (1975: 289) thoroughly discussed morphological criteria and the classification of the Nitschkiaceae. He excluded some genera which had previously been included in the family, e.g. **Thaxteria** Sacc., and accepted only 5 genera. Nannfeldt assigned these genera into three groups, with regard to the morphology of the ascomata, and concluded that the differences between the groups are not so profound that separate families should be recognized. These groups are commented upon below.

Group 1 (= Nitschkiaceae s. str.).
Acanthonitschkea Speg., **Gaillardiella** Pat., and **Nitschkia** Otth ex Karsten. - This group is characterized by comparatively small ascomata (usually less than 500 µm), which are smooth or spiny, often collapsing, without an ostiole, but with a unique opening mechanism, the "Quellkörper", consisting of conglutinated hyaline, scleroplectenchymatous cells, or with this structure replaced by a low, perforated cushion. The asci are thin-walled, long-stalked and produce, in most species, a large number of small, hyaline, 1-septate spores which germinate by hyphae. A small ring is seen in the ascus top in some species (Cotton Blue!), but Nannfeldt (1975: 301) is of the opinion that it has lost its gun-function and that the ascus wall usually deliqueses rather early.

Group 2 (= Coronophoraceae).
Coronophora Fuckel. - This is the type of the family "Coronophoreen" Höhnel (an illeg. name; International Code of Botanical Nomenclature, article 18). In this genus the ascomata are usually larger than 500 µm (up to almost 2 mm), commonly non-tuberculate, have a periphysate ostiolar channel (Parguey-Leduc 1967: 27, Fig. 51) , and shrivel irregularly upon drying. The asci are thick-walled above the long and narrow stalk, except at the apex where there is a wide sub-apical chamber, capped by a thin, refringent apical dome (Parguey-Leduc, l.c.). They produce a very large number of small, allantoid, 1-septate, hyaline ascospores.

Group 3 (= Bertiaceae).
Bertia De Not. - This genus should have an isolated position in the family (Nannfeldt 1975: 299, 303). Smyk (1981: 47) erected the new family Bertiaceae. The illustrations of the type species **B. moriformis** indicate that another species was studied (Corlett & Krug 1984: 2566; Eriksson 1984: 54), however, the family name is validly published and available for **Bertia** and closely related genera if it turns out that this group should be recognized as a separate family. In fact, there may be reasons for accepting this family. Since 1975, when Nannfeldt published his paper, some genera have been found to be intermediate between the Nitschkiaceae s. str. and the Lasiosphaeriaceae. Nannfeldt (1975: 305) mentioned **Lasiosphaeria noonae-daniae** Carroll & Munk. This is the type of **Lasiosphaeriella** Sivanesan (1975). **Rhagadostoma** Körber (see D. Hawksworth and Sivanesan in Hawksworth 1980: 373) also belongs to this group, as does **Lasiosphaeriopsis**. Most species in these four genera have comparatively large ascomata (usually more than 500 µm). They are thick-walled, ±-tuberculate, have a stromatic base and an ostiolar channel lined with periphyses. The asci are thin-walled, persistent and 2-8-spored. The ascospores are large, hyaline to dark brown, usually with more than one septum, and they germinate by phialides. **Spinulosphaeria** Sivanesan (1974: 35) and **Thaxteria** Sacc. may also be members of this group (cf. Nannfeldt 1975: 290).

Lasiosphaeriopsis differs from the other genera in the group by virtue of their mature dark brown spores without a perispore. **Lasiosphaerella** has similar spores, but with a perispore.

This group is certainly related to the two other groups, and we prefer not to recognize the three groups as separate families. More studies are needed of the morphology and ontogeny of the ascomata of both the Nitschkiaceae and the Lasiopsphaeriaceae. The position of, for instance, **Lasiobertia** Sivanesan (1978: 383) is uncertain. This is an aberrant monotypic genus with non-ostiolate, tuberculate, scattered or aggregated ascomata with paraphyses and asci with amyloid ring. The spores are hyaline, fusiform, 1-septate. The "Munk pores", according to Sivanesan, should not be as prominent as in "Coronophorales". The presence of paraphyses and amyloid asci are especially remarkable.

In all Nitschkiaceae s. lat. there are distinct "Munk pores" in the ascomal wall. They are not as abundant in **Lasiosphaeriopsis stereocaulicola** as in, for example, **Bertia moriformis**. In semithin sections of the latter species we have seen numerous pores, not only in the coloured, thick-walled outer cells, but also in the hyaline, thin-walled cells lining the ascomal cavity. We can confirm Nannfeldt's observation (1975: 294) that there may be more than one pore/cell.

It is probable that the Nitschkiaceae s. str. have evolved from fungi resembling species in group 3, i.e. the Bertiaceae if a separate family was recognized. The ostiole and the periphyses have dissappeared in almost all species. Thin-walled cells resembling periphyses occur in, e.g., **Nitschkia leonensis** (Sivan.) Nannf. (see Nannfeldt 1975: 298), and may be considered a primitive feature.

ACKNOWLEDGEMENTS

We would like to thank Dr. Yue Jing-zhu for three of the drawings and for technical assistance in producing semithin sections and scanning graphs. We are grateful to Dr. B.C. Sutton for the loan of type material from IMI. We also thank Dr. Vicky Shingler for reading the manuscript.

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MYCOTAXON

Vol. XXV, No. 2, pp. 581-601 April-June 1986

BIOGEOGRAPHY OF FUNGAL ECTOPARASITES OF TERMITES

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Termites are unusual among insects in that they are hosts for at least 20 species of obligate ectoparasitic fungi, most of which are restricted to this insect group. Literature reports and recent collections indicate that Termitaria, Antennopsis, and Laboulbeniopsis are widely distributed throughout the world. Geographical ranges of species of Dimeromyces, Laboulbenia, Hormiscioideus, Coremycetopsis, Mattirolella, and some of Termitaria are restricted. Strict host specificity was not observed; however, T. coronata was more common on termitid hosts, while T. snyderi has been found on a variety of host families, except termitids.

INTRODUCTION

At least twenty species of fungi in nine genera are obligate parasites of termites and some of their termitophiles; one additional genus, Amphoromorpha, is found on a wider range of hosts (Table 1). Only Cordycepioideus bisporus Stifler and C. octosporus M. Blackwell et Gilbertson appear to be serious pathogens. Most of the fungi are minute and cannot be seen easily except at higher dissecting microscope magnifications (x40 and above). Exceptions are species of Cordycepioideus Stifler, Termitaria Thaxter, and Mattirolella Colla which

TABLE 1
FUNGAL GENERA

TERMITE HOSTS[1]	Laboulbenia	Dimeromyces	Cordycepioideus	Laboulbeniopsis	Coreomycetopsis
KALOTERMITIDAE					
MASTOTERMITIDAE					
HODOTERMITIDAE					
HODOTERMITINAE	Libya(1)[2]				
TERMOPSINAE					
POROTERMITINAE					
CRETATERMITINAE					
STOLOTERMITINAE					
RHINOTERMITIDAE					
STYLOTERMITINAE					
TERMITOGETONINAE					
PSAMMOTERMITINAE					
HETEROTERMITINAE		Florida(1)		U.S., Italy French Guiana	U.S.
COPTOTERMITINAE					
RHINOTERMITINAE					
SERRITERMITIDAE					
TERMITIDAE					
AMITERMITINAE	Ghana(5)	Kenya(2)			
TERMITINAE					
MACROTERMITINAE	Kenya(2), Ethiopia(2,4), Mozambique(3)		Tanzania(1), Kenya(1)		
NASUTITERMITINAE			Mexico(2)	Sierra Leone, Indochina, Indonesia, Sumatra, Grenada	Grenada

[1]Termite classification is based on Krishna (1970). Although other classifications have been proposed more recently they do not substantially reclassify termites which serve as hosts for fungi.
[2]Numbers in parentheses refer to species in figure legends.

TABLE 1, continued

TERMITE HOSTS	Amphoromorpha	Hormiscioideus	Antennopsis	Termitaria	Mattirolella
KALOTERMITIDAE			Yugoslavia(1) Madagascar(3)	Brazil(1) Samoa(1)	
MASTOTERMITIDAE				Australia(6)	
HODOTERMITIDAE					
HODOTERMITINAE				South Africa(2)	
TERMOPSINAE					
POROTERMITINAE				Chile(1), Australia(5)	
CRETATERMITINAE					
STOLOTERMITINAE					
RHINOTERMITIDAE					
STYLOTERMITINAE					
TERMITOGETONINAE					
PSAMMOTERMITINAE					
HETEROTERMITINAE	Florida		France(1), Italy(1), U.S.(1)	U.S.(1), Europe(1)	
COPTOTERMITINAE			New Guinea(2), French Guiana(2)	Sierra Leone(2) Australia(4)	
RHINOTERMITINAE			Indochina(1), Sumatra(2)	British Guiana(1)	Panama(1), British Guiana(2)
SERRITERMITIDAE					
TERMITIDAE					
AMITERMITINAE			Sierra Leone(2)	South Africa(2), Namibia(2) Sierra Leone(2), Kenya(2), Indochina(2)	
TERMITINAE				South Africa(2)	
MACROTERMITINAE	Sierra Leone			Swaziland(2)	
NASUTITERMITINAE		Brazil	Guadeloupe(2), Sumatra(2), Indonesia(2)	Australia(2), Indochina(2), Kenya(2), British Guiana(2) French Guiana(2) Philippines(2), Costa Rica(2), Brazil(3)	Panama(1)

often are visible to the unaided eye. It is probably no coincidence that the highly visible Termitaria, while relatively common, is the best known of these fungi.

Information on geographical and host ranges of the termite fungi was reviewed by Blackwell and Kimbrough (1978). Since that time additional reports on fungal taxonomy, host relations, and geographical and host ranges have been published (Rossi and Cesari Rossi, 1977; Blackwell, 1980; Blackwell and Gilbertson, 1981; Kimbrough and Thorne, 1982; Thorne and Kimbrough, 1982; Kimbrough and Lenz, 1982; Lenz and Kimbrough, 1982; Blackwell and Gilbertson, 1984; and Rossi and Blackwell, 1986). These and the records reported here make feasible a preliminary discussion of the worldwide distributions of the fungi in relation to the phylogeny and distributions of the termite hosts.

METHODS AND MATERIALS

Termites infested with fungi were acquired by one of us (W. R.) from the following sources: termites from Sierra Leone, Kenya, and Australia, were collected by W. Rossi (stored in 75% alcohol, 2% glycerine in water); from Indonesia, Central America, and South America, by J. Balazuc (stored in denatured alcohol); Indochina, Museum of Natural History of Paris, by J. Balazuc; and South Africa, Namibia, and Swaziland, J. E. Ruelle, Plant Protection Research Institute, Pretoria. Termites from U.S.A. localities were collected by M. Blackwell and preserved in 75% ethanol.

Termites infested with Termitaria spp. were oriented in 40% mucilage and frozen for cryostat sectioning. Other fungal specimens were removed with a small portion of the insect integument for direct mounting. All fungi were mounted in glycerine-containing acid fuchsin (Benjamin, 1971) on microscope slides with glass cover slips. After several days the cover slips were sealed with clear fingernail polish. Fungal species identifications were made from the original descriptions cited herein.

A great amount of literature on the biology of termites has been made available in the two volumes edited by Krishna and Weesner (1969, 1970). We have drawn heavily from this work for information on termite classification, phylogeny, biogeography, and biology; however, some additional references are also cited. Termite scientific names are those standardized by

Snyder's catalog (1949) or those from more recent species descriptions. Termites were kindly identified by S. Bacchus, British Museum (Natural History), London.

FUNGI ASSOCIATED WITH TERMITES

ASCOMYCETES

LABOULBENIALES

Laboulbenia Mont. et Robin

L. hagenii Thaxter. On Macrotermes michaelseni (Sjöstedt) (as Termes bellicosus var. mozambica), Africa (Thaxter, 1895).

L. felicis-caprae W. Rossi. On Anacanthotermes ochraceus (Burmeister), Libya (Rossi, 1974).

L. geminata Buchli ex W. Rossi et M. Blackwell. On Odontotermes badius (Haviland), Ethiopia (Buchli, 1966); on Odontotermes sp., Kenya (Buchli, 1966).

L. ghanaensis W. Rossi et M. Blackwell. On Amitermes evuncifer Silvestri, Ghana (Rossi and Blackwell, 1986).

L. brignolii W. Rossi et M. Blackwell. On Macrotermes herus (Sjöstedt), Ethiopia (Rossi and Blackwell, 1986).

Dimeromyces Thaxter

D. isopterus Kimbrough. On Reticulitermes flavipes (Kollar), Florida (Kimbrough et al., 1972; Kimbrough, 1986); on staphylinids, mites, Mississippi, Florida (Blackwell, Samson, and Kimbrough, 1980).

D. majewskii W. Rossi et Cesari. On Alyscotermes kilimandjaricus (Sjöstedt), Kenya (Rossi and Cesari Rossi, 1977).

Both laboulbeniomycete genera, Laboulbenia and Dimeromyces, occur on a wide variety of arthropod hosts. They are known from species of Coleoptera, Orthoptera, Isoptera, and mites; Laboulbenia is known also on hymenopteran, dipteran, and hemipteran hosts; Dimeromyces, from dermapterans. Species of the two genera are the only members of the Laboulbeniomycetes known from both isopterans and gryllid orthopterans (Tavares, 1980).

Laboulbenia species on termites are restricted to Africa (Fig. 1). The host species are usually inhabitants of the more arid regions of the continent (Bouillon, 1970; Noirot, 1970) and are classified in two very different termite families (Table 1). Distribution of the termite

Fig. 1. Distribution of Dimeromyces isopterus (①), D. majewskii (②), Laboulbenia felicis-caprae (❶), L. geminata (❷), L. hagenii (❸), L. brignolii (❹), and L. ghanaensis (❺). Fig. 2. Distribution of Hormiscioideus filamentosus (○), Cordycepioideus bisporus (❶), and C. octosporus (❷).

genera is confined to Ethiopian and Oriental regions in the case of Odontotermes and Macrotermes, Oriental and Palearctic regions for Anacanthotermes (Roonwal, 1970; Harris, 1970). The restricted geographical and climatic ranges of the species of Laboulbenia may indicate a relatively recent association of Laboulbenia with termites. There is no host specificity within termite families or subfamilies.

While Dimeromyces isopterus is known from a single locality in Florida on Reticulitermes flavipes (Fig. 1, Table 1), two of its termitophiles were also infected in Florida and Mississippi (Blackwell, Samson, and Kimbrough, 1980). In fact, staphylinid beetles and mites associated with the termites are more heavily infected than termites (Kimbrough, personal communication). Although R. flavipes and other subterranean termites are common in the southern United States and are often collected and examined for D. isopterus, no additional collections of the fungus have been made.

Dimeromyces majewskii is known only from the type collection in Kenya. This species is morphologically quite different from D. isopterus. It is more likely that the occurrence of D. majewskii on Kenyan termites represents an independent evolutionary host change than evolution of the two species from a common Dimeromyces ancestor.

HYPOCREALES

Cordycepioideus Stifler

C. bisporus Stifler. On Macrotermes natalensis (Haviland), Tanzania (Stifler, 1941); on M. michaelseni, Kenya; on M. cf. subhyalinus (Rambur), Kenya (Blackwell and Gilbertson, 1984).

C. octosporus M. Blackwell et Gilbertson. On Tenuirostritermes tenuirostris (Desneax), Mexico (Blackwell and Gilbertson, 1981).

Superficially these two species resemble Cordyceps spp. The African species, C. bisporus, is certainly more common than the original report (Stifler, 1941) indicates (Blackwell and Gilbertson, 1984). Cordycepioideus octosporus is known only from the type collection in Mexico. The disjunct range (Fig. 2) would indicate a wider historical, if not present, range for the genus; it is probably a reflection of inadequate collection. Termite hosts are genera in two subfamilies of the higher

termite family Termitidae (Table 1). Macrotermes is distributed in Oriental and Ethiopian regions, while Tenuirostritermes occurs in the New World tropics and north to Arizona and Texas (Krishna, 1970).

UNCERTAIN AFFINITY

Laboulbeniopsis Thaxter

L. termitarius Thaxter. On Nasutitermes costalis (Holmgren) (as Eutermes morio), Grenada (Thaxter, 1920); on Reticulitermes flavipes, Florida (Kimbrough and Gouger, 1970; Blackwell and Kimbrough, 1976b), Georgia (Blackwell, 1980), Michigan, Louisiana (reported here); on R. virginicus Banks, Florida (Kimbrough and Gouger, 1970); on R. lucifugus Rossi, Italy (Rossi and Cesari Rossi, 1977b); on Leptomyxotermes doriae (Silvestri), Sierra Leone (reported here, MB 55); on Ahmaditermes sp., Indochina (reported here, MB 35, MB 39); on Nasutitermes sp., Indonesia (reported here, MB 37); on Nasutitermes sp., Sumatra (reported here, MB 41); on Coptotermes crassus Snyder, French Guiana (reported here, MB 44).

Laboulbeniopsis termitarius was previously known from Grenada, Florida, Georgia, and Italy. The geographical range now has been extended to include a more northern part of the United States (Michigan), South America, Africa, and southeastern Asia (Fig. 3), (see below, Coreomycetopsis).

The termite host genera (Table 1) have broad ranges throughout the tropics of the world, except Reticulitermes which is widely distributed in Nearctic and Paelarctic regions.

DEUTEROMYCETES

UNCERTAIN AFFINITY

Coreomycetopsis Thaxter

C. oedipus Thaxter. On Nasutitermes costalis (as Eutermes morio), Grenada (Thaxter 1920); on Reticulitermes virginicus, Florida (Blackwell and Kimbrough, 1976a); on R. flavipes, Georgia (Blackwell, 1980).

The collections of C. oedipus reported in the literature all have occurred in termite populations also associated with Laboulbeniopsis termitarius, not only sometimes on the same insect individual, but often on a single leg or antenna (Fig. 3, Table 1). The small

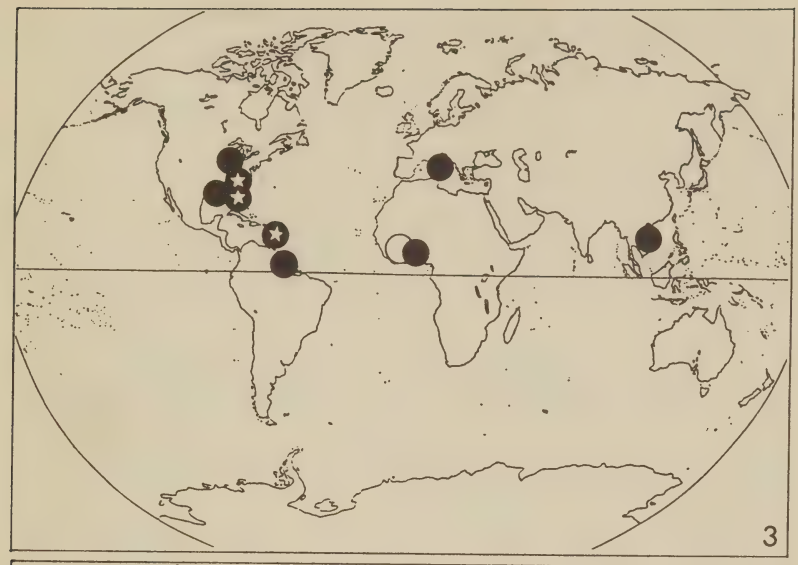

Fig. 3. Distribution of Amphoromorpha spp. (○), Laboulbeniopsis termitarius, (●) and Coremycetopsis oedipus (☆). Fig. 4. Distribution of Antennopsis gallica (①), A. gayi (②), and A. grassei (③).

colorless thallus of C. oedipus is difficult to distinguish from termite spines and this may account partially for the smaller known host and geographical ranges of this species when compared to L. termitarius, which has a darkened foot cell. However, careful examination of new L. termitarius-infected termite collections and all other new collections has failed to discover additional specimens of C. oedipus.

Blackwell and Kimbrough (1976a, 1976b) studied the development of C. oedipus and L. termitarius and came to the conclusion that spore production in L. termitarius appeared to be by free cell formation, while C. oedipus produced phialoconidia. Thaxter (1920) had noticed that spores of L. termitarius were formed simultaneously. Early stages of development of both species were found which clearly indicated C. oedipus developed only from phialospores, and L. termitarius, only from ascospores. These observations were important because it has been suggested the two forms comprised the holomorph of a single species. While the two species must surely be related because of the great similarity of ultrastructural detail of foot cell and thallus development until spore formation, they are distinct. The possibility that C. oedipus is restricted to the New World provides additional evidence for their autonomy.

Amphoromorpha Thaxter

Amphoromorpha sp. On Acanthotermes acanthothorax (Sjöstedt), Sierra Leone (reported here, MB 56).

Amphoromorpha entomophila Thaxter was described from bristles of a staphylinid beetle (Thaxter, 1914). It was also reported from two additional staphylinids and an earwing from the Philippines. Other forms which differ primarily in size and position on insects are known from beetles, roaches, a simulid, millipedes, and pseudoscorpions (Thaxter 1914, 1920; Spegazzini, 1918; Blackwell, unpublished observation; Rossi and Balazuc, 1977; Rossi, unpublished observation); the genus also has been reported from mucoralean (Benjamin, personal communication) and laboulbenialean fungi (Thaxter, 1914; Rossi and Cesari Rossi, 1979, 1982).

The specimen of Amphoromorpha sp. from Western Africa consists of one thallus on the right hind leg of a termite. It falls within the limits of Thaxter's (1914) description of A. entomophila except that the thallus is slightly longer (135 μm). A species of Amphoromorpha has

been observed several times on Reticulitermes spp. in Florida (J. W. Kimbrough, personal communication).

The taxonomy of Amphoromorpha and other minute entomogenous forms is difficult because so few characters are available for distinguishing species. Developmental events and geographical and host distributions are poorly known for these species. Thalli often occur in small numbers on termites and few insects in a population are infested. Amphoromorpha is known from one tropical and one subtropical locality on termite species which are not closely related (Fig. 3, Table 1).

Hormiscioideus M. Blackwell et Kimbrough

H. filamentosus M. Blackwell et Kimbrough. On Armitermes neotenicus Holmgren, Brazil (Blackwell and Kimbrough, 1978).

Hormiscioideus filamentosus is known only from the type collection in which 60% of the termites were heavily infected. The termite genus is Neotropical in distribution and is restricted to damp woodlands (Fig. 2, Table 1).

GLOEOHAUSTORIALES

Antennopsis Heim

A. gallica Heim et Buchli. On Reticulitermes lucifugus santonensis Feytaud, France (Heim, 1951); on R. virginicus; on R. flavipes, Florida (Gouger and Kimbrough, 1969), Georgia (Blackwell, 1980), Wisconsin, Michigan (reported here); on Reticulitermes sp., Louisiana (reported here); on Kalotermes (as Calotermes) flavicollis (Fabricius), Yugoslavia (Buchli, 1960); on Reticutitermes lucifugus (Rossi), Italy (Rossi and Cesari Rossi, 1977b).

A. grassei Buchli (nomen nudum). On Neotermes amplus Sjöstedt; on N. desneuxi (Sjöstedt); on Glyptotermes longiceps Paulian, Madagascar (Buchli, 1960).

A. gayi Buchli (nomen nudum). On Coptotermes elisae (Desneux); on C. obiratus Hill, New Guinea (Buchli, 1966); on Nasutitermes costalis (Holmgren), Guadeloupe (reported here, MB 36); on Nasutitermes sp., Indonesia (reported here, MB 41); on Amitermes evuncifer Silvestri, Sierra Leone (reported here, MB 42).

Although the thallus of Antennopsis species is small, it is darkly pigmented and shows up distinctly against the nonpigmented termite. The genus is known from North America, including new reports from the northern United

States, South America, Europe, Africa, Madagascar, southeastern Asia, and New Guinea (Fig. 4).

Three species names exist in the literature. Antennopsis gallica Heim et Buchli (Heim, 1951) is validly described. Antennopsis grassei and A. gayi are nomina nuda proposed by Buchli (1960, 1966). Gouger and Kimbrough (1969) suggested that A. grassei may in fact be distinct from A. gallica, but were doubtful of the status of A. gayi. However, we have seen several new collections of Antennopsis (MB 36, MB 41) which fit the description of A. gayi. Because the three forms are recognizable on the basis of extant collections, we maintain the distinctions but do not validate the two taxa until more is known of developmental histories and distributions.

Termite hosts of Antennopsis (Table 1) are found in the Kalotermitidae, three subfamilies of the Rhinotermitidae (Heterotermitinae, Coptotermitinae, and Rhinotermitinae), and the Termitidae (Nasutitermitinae). All host genera have extremely broad ranges in tropical areas of the world. In addition Reticulitermes species are widely distributed in Paelarctic and Nearctic regions.

TERMITARIALES

Termitaria Thaxter

T. snyderi Thaxter. On Reticulitermes virginicus, Washington, DC (Thaxter, 1920), Florida (Khan and Kimbrough, 1974); on R. flavipes, Washington, DC, Massachusetts (Thaxter, 1920)), Florida (Khan and Kimbrough, 1974), Georgia (Blackwell, 1980); on Reticulitermes sp., California (Thaxter, 1920); on Rhinotermes marginalis (L.), British Guiana (Thaxter, 1920); on Porotermes quadricollis (Rambur), Chile (Colla, 1929); on Reticulitermes lucifugus, Italy (Thaxter, 1920; Rossi and Cesari Rossi, 1977b); on Neotermes (as Calotermes) samoanus Holmgren, Samoa (Tate, 1927, 1928).

T. coronata Thaxter. On Nasutitermes costalis (as Eutermes morio), Grenada (Thaxter, 1920); on Nasutitermes corniger (Motschulsky) (as Eutermes costaricensis), Costa Rica; on Nasutitermes guayanae (Holmgren); on N. surinamensis (Holmgren), British Guiana (Colla, 1929); on N. costalis, Guadeloupe (reported here, MB 36); on N. maximus (Holmgren), French Guyana (reported here, MB 46); on Amitermes evuncifer Silvestri (reported here, MB 42); on Coptotermes sjostedti Holmgren, Sierra Leone (reported here, MB 45); on Microcerotermes fuscotibialis (Sjöstedt),

Sierra Leone (reported here, MB 54); on Microcerotermes sp., Kenya (reported here, MB 52); on Nasutitermes cf. kempa Harris, Kenya (reported here, MB 53); on Odontotermes badius (Haviland), Swaziland (reported here, MB 40); on Allodontermes schultzei (Silvestri), Namibia (reported here, MB 59), South Africa (reported here, MB 48); on Allodontermes rhodesiensis (Sjöstedt), South Africa (reported here, MB 47, MB 49); on Nasutitermes fumigatus (Brauer) (reported here, MB 36); on N. exitiosus (Hill); on N. longipennis (Hill); on Mastotermes darwiniensis Froggatt; on Porotermes adamsoni (Froggatt), on Coptotermes lacteus (Froggatt); on C. acinaciformis (Froggatt), Australia (Kimbrough and Lenz, 1982).

T. macrospora Kimbrough et Lenz. On Mastotermes darwiniensis, Australia (Kimbrough and Lenz, 1982).

T. rhombicarpa Kimbrough et Lenz. On Porotermes adamsoni Australia (Kimbrough and Lenz, 1982).

T. longiphialidis Kimbrough et Lenz. On Coptotermes lacteus; on C. acinaciformis, Australia (Kimbrough and Lenz, 1982).

T. thaxteri Reichensperger. On Cornitermes cumulans (Kollar); on Nasutitermes (as Eutermes) rippertii (Rambur); on Nasutitermes (as Eutermes) arenarius (Hagen), Brazil (Reichensperger, 1923).

Termitaria spp. On Nasutitermes (as Eutermes) sp.; on Nasutitermes maculiventris (Sjöstedt) (as Eutermes lujae), Belgian Congo (Reichensperger, 1923); on Microhodotermes viator (Latreille) (as Hodotermes thompsoni), South Africa (Reichensperger, 1923); on Reticulitermes lucifugus, France (Feytaud and Dieuzeide, 1927); on Reticulitermes sp., U.S. (?) (Pickens, 1952).

Species of the genus Termitaria are the best known of all termite ectoparasites. As mentioned in the introduction they are easily observed because of their relatively large size and dark pigmentation. Not only are the fungi wide spread geographically (Fig. 5), they also have a broad range of termite hosts which include species in five of the six extant termite families (Table 1).

The new reports included here indicate that T. coronata is more common on termitid hosts with only one record on a rhinotermitid species. Termitaria snyderi is known on rhinotermitid hosts (Rhinotermitinae, Coptotermitinae, and Heterotermitinae) and on Kalotermitidae. Termitaria snyderi appears to be more common in temperate regions of the Northern Hemisphere, while T. coronata is known from tropical and Southern

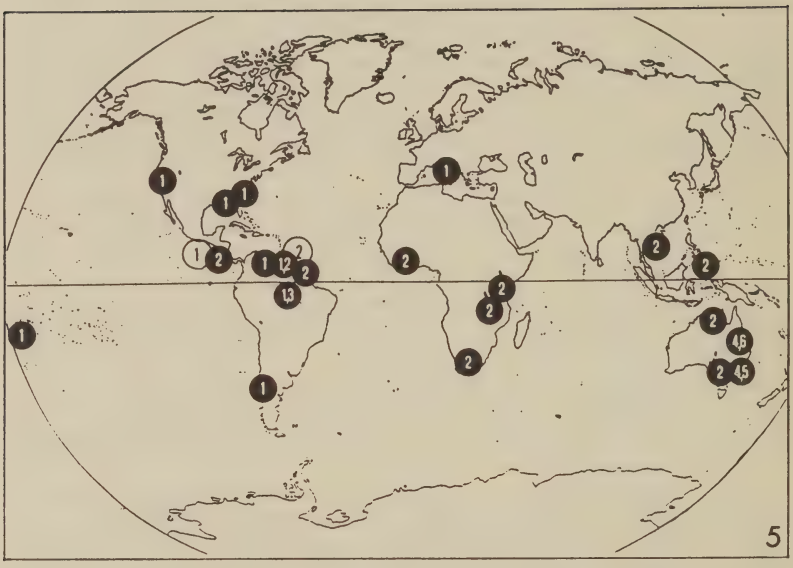

Fig. 5. Distribution of Mattirolella crustosa (①), M. silvestrii (②); and Termitaria snyderi (❶), T. coronata (❷), T. thaxteri (❸), T. longiphialidis (❹), T. rhombicarpa (❺), and T. macrospora (❻).

Hemisphere localities. The occurrence in Australia of four species (Kimbrough and Lenz, 1982), some sympatric on the same host species, is unique for the genus.

Mattirolella Colla

M. silvestrii Colla. On Rhinotermes marginalis, British Guiana (Colla 1929).

M. crustosa Khan et Kimbrough. On Reticulitermes sp., Panama (Khan and Kimbrough, 1974); on Nasutitermes corniger; on N. ephratae (Holmgren); on N. columbicus (Holmgren), Panama (Kimbrough and Thorne, 1982).

Khan and Kimbrough (1974) and Kimbrough and Thorne (1982) have discussed the close relationship of species of

Mattirolella and Termitaria. Both host range (Rhinotermitinae and Nasutitermitinae) and distribution (Central America and northern South America) of Mattirolella species overlap with those of Termitaria; however, Termitaria has a far wider distribution (Fig. 5, Table 1).

DISCUSSION

Termites are unusual as fungal hosts. No other insect group is known to harbor so many minute, nonmycelial fungi, most of which are restricted to termites. Isopterans are a very old group. Fossils are known from rocks at the Lower-Upper Cretaceous border in Labrador (Emerson, 1967). Emerson speculated on the basis of this find that the group may extend as far back as the Mesozoic or even Late Paleozoic. The primitive family Mastotermitidae is represented by one extant species in Australia; however, the family was worldwide in Early and Middle Tertiary (Emerson, 1965). Baltic amber (Oligocene) contains a fauna which is essentially modern and characteristic of a present day warm temperate European fauna. Miocene age amber from Chiapas contains termites similar to those of recent Neotropical faunas (Wilson, 1971).

In addition to their age which has afforded time for development of the associations, termites also maintain a temperature-stable, humid environment and provide an efficient means of local dispersal for the fungi. Dispersal of spores is probably by direct contact with termite-infested fungi or spores released into termite galleries and nests. Large populations of these social insects within a restricted area help to insure the contact necessary for spore dispersal to suitable hosts. Opportunity for interspecific infection is afforded by many instances of inquilinism involving several termite species, commensalism with other insects and mites, and use of abandoned nests and galleries of one species by other species of termites.

Dispersal over long distance does not appear to be too efficient. Although some termite individuals are winged at some stage in their life, they are unable to fly great distances. Large bodies of water serve as effective barriers to termite dispersal (Krishna, 1969); however, the insects are capable of crossing smaller water barriers, and they are known from net captures up to 1000

km from land (Gressitt, 1961). Termites are essentially a tropical group as is shown by both their fossil record and present distribution; extreme cold also serves as an effective barrier to dispersal (Krishna, 1969). The occurrence of a molt prior to alate maturation serves to remove fungal ectoparasites and, thereby, further reduces the possibility long distance dispersal.

Of the ten genera of fungi which infest termites, few appear to be closely related. Some species have a basal cell which may produce a secretion to cement the fungus to the exoskeleton (Amphoromorpha, Coreomycetopsis, and Laboulbeniopsis). In other cases (Termitaria, Antennopsis, Hormiscioideus, Laboulbenia, Dimeromyces, Mattirolella) a restricted haustorial system is present. Only Cordycepioideus is mycelial. The presence of so many nonmycelial forms may be a reflection of convergence selected by the stable, protected environment. This suggestion has been made for laboulbenialean and other fungi discussed here (Benjamin, 1971).

Amphoromorpha is known from a variety of nontermite hosts. Thaxter (1920) did not consider this genus to be related to the other nonhaustorial forms, Coreomycetopsis and Laboulbeniopsis. However, there is some evidence that Coreomycetopsis and Laboulbeniopsis may be related (Blackwell and Kimbrough, 1976a, 1976b), (see above, Coreomycetopsis). Relationships between these genera and other nonmycelial forms on a variety of hosts has been discussed recently (Blackwell et al., 1986).

The morphology of Termitaria and Mattirolella is complex enough that their high degree of similarity is certainly an indication of a close relationship (Khan and Kimbrough, 1974; Kimbrough and Thorne, 1982). A third genus, Termitariopsis, is part of this complex and is known on ants in Kansas and Panama (Blackwell et al., 1980). Mattirolella and Termitariopsis occur in isolated portions of the wide range of Termitaria. Some degree of speciation has occurred in Australia where four species occur on a variety of termites and are sympatric on the same host in several cases (Kimbrough and Lenz, 1982).

The two laboulbenialean genera, Dimeromyces and Laboulbenia, are not closely related to each other. Collections of D. isopterus have been made only in the southeastern United States and the species does not appear to be common on termites. The more common presence of D. isopterus on staphylinid commensals than on Reticulitermes and the prevalence of beetle and staphylinid hosts for

Dimeromyces may be a clue to a way in which extreme host changes come about. The occurrence of D. majewskii on termites probably represents a second independent host change. It will be important to determine if commensals associated with the host termites also are infected with D. majewskii. Such information may substantiate the idea that host shifts occur through ecological associations between unrelated hosts. The five species of Laboulbenia are restricted to arid regions of Africa. Indications from the present restricted geographical and host ranges of these two genera are that they have only recently become associated with termite hosts. The five species of Laboulbenia in Africa may have evolved from a common ancestor under the same conditions which led to development of a number of endemic termite species (Rossi and Blackwell, 1986).

Because cold climates and large bodies of water serve at least as partial barriers for termite dispersal, it seems reasonable to suggest that the fungal genera Termitaria, Antennopsis, and Laboulbeniopsis are very old and were established in termite populations which were the early colonizers of the continents. Cordycepioideus known from Africa and Mexico may also have had a similar history.

Although species of termites with broad geographical and host ranges appear morphologically similar throughout their entire range across continents and hosts (i.e., T. coronata, T. snyderi, Antennopsis gallica, Laboulbeniopsis termitarius), undetectable physiological differences could exist. It is likely that the stable, protected environment of the termite acts to maintain constant morphological features in the fungi.

Only one fungal species shows some restriction to related host species. Termitaria coronata is much more common on termitid hosts of the subfamilies Amitermitinae and Nasutitermitinae. Although T. snyderi has been collected from a variety of termites it is not yet known from any termitid.

Additional, intensive collection is needed to provide information on complete host and geographical ranges for these fungi. It will be particularly interesting to determine if Mattirolella spp., Cordycepioideus bisporus, C. octosporus, Hormiscioideus filamentosus, Termitaria rhombricarpa, T. longispora, T. macrocarpa, Laboulbenia spp., Dimeromyces isopterus, and Coreomycetopsis oedipus really do have the restricted ranges indicated by the

present reports. Because of the low incidence of fungal infection in many insect populations, the aid of entomologists who study the insects is imperative for obtaining specimens efficiently.

We are happy to acknowledge the contribution of S. Bacchus, J. E. Ruelle, and J. Balazuc, their help in identification and acquisition of termite specimens.

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MYCOTAXON

Vol. XXV, No. 2, pp. 603-605 April-June 1986

FLAVOPARMELIA, A NEW GENUS IN THE LICHEN FAMILY PARMELIACEAE (ASCOMYCOTINA)

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Abstract.--The genus Pseudoparmelia Lynge is limited to a group of four tropical species, P. cyphellata Lynge, P. chapadensis (Lynge) Hale, P. hypomilta (Fée) Hale and P. sphaerospora (Nyl.) Hale. Of the other 72 species formerly assigned to Pseudoparmelia, 17 usnic acid-containing species (the P. caperata group) are segregated in a new genus, Flavoparmelia.

The genus Pseudoparmelia Lynge was based on one species, P. cyphellata (Lynge, 1914). This rare Brazilian lichen is in fact closely related to three other species: P. hypomilta (Fée) Hale, another rarely collected Brazilian lichen with an orange-red pigmented medulla; P. chapadensis (Lynge) Hale, a saxicolous species, also from Brazil; and P. sphaerospora (Nyl.) Hale, a widespread corticolous lichen in the American tropics and Africa. All four species share an unidentified pale yellow medullary pigment (?secalonic acid), rarely contain stictic or hypostictic acid in the medulla, and sporadically have traces of atranorin in the cortex. The thallus is often quite yellowish, however, apparently because of low concentrations of the medullary pigment in the cortex. The lower surface is shiny and pale brown or uniquely olivaceous brown with simple, rather sparse rhizines. The spores are small (about 6 X 9 µm) and nearly spherical, and the conidia are cylindrical to weakly bifusiform.

When I resurrected Pseudoparmelia in 1976 (Hale, 1976), I included in it not only these four species but another 72 from the old form genus Parmelia (mostly in sect. Cyclocheila) which lacked marginal cilia and had adnate lobes and simple rhizines with at most a narrow bare or papillate zone at the margin below. I realized at the time that my delimitation of Pseudoparmelia was heterogeneous in terms of chemistry, morphology and geography.

Research in the past few years by several investigators has begun to elucidate some of the discontinuities within Pseudoparmelia sens. lat. and pointed the way to more rational, natural generic divisions. It now appears, for example, that Pseudoparmelia should include only the four species mentioned above with their characteristic spore size and thalline chemistry, and that the other 72 species should be removed to other genera. I will discuss one group here, the well-known P. caperata group.

Parmelia caperata has always posed problems for workers in Parmelia. I placed it in Pseudoparmelia because of the lack of cilia, even though it has rather broad, apically rotund lobes. The lobes are, in fact, almost wide enough to fit the concept of Parmotrema Mass. (Parmelia subgenus Amphigymnia), but the bifusiform conidia exclude it from that genus. Gyelnik (1932) actually created a subsection Eciliatae under section Subflavescentes (= Amphigymnia) to accomodate P. caperata.

There are other characters which set P. caperata and 16 related species apart from the remainder of Pseudoparmelia sens. lat.: The constant presence of usnic acid in the cortex (at most with traces of atranorin), a lichenin negative reaction (Imshaug, in litt.), the black lower surface with simple rhizines and a distinct narrow bare zone below at the margins, the large spores (mature spores more than 15 μm long with an episporium about 2 μm thick), and nearly constant occurrence of the protocetraric acid group (protocetraric acid, fumarprotocetraric, malonprotocetraric acid and physodalic acid), often with fatty acids. All are temperate species, occurring frequently in dry to semi-arid forested regions.

I believe that the P. caperata group is not at all related to Pseudoparmelia sens. str. or to any of the other species groups formerly placed in the genus and constitutes a new genus, Flavoparmelia, as described below:

Flavoparmelia, gen. nov.

Thallus foliaceus, adnatus vel laxe adnatus, lobis subirregularibus, apice rotundatis, margine eciliatis, cortice superiori epicorticato, subtus niger, modice rhizinosus, rhizinis simplicibus, nigris. Apothecia adnata, imperforata, sporis octonis, simplicibus, conidiis bifusiformibus.

Type: Lichen caperatus L.

This genus contains 17 species (see Hale, 1976 for full descriptions and synonymy):

Flavoparmelia amplexa (Stirton) Hale, comb. nov.
Parmelia amplexa Stirton, Trans. Glasgow Soc. Field Nat. 5:212. 1877.
Pseudoparmelia amplexa (Stirton) Hale, Smith. Contr. Bot. 31:16. 1976.

Flavoparmelia baltimorensis (Gyel. & Fór.) Hale, comb. nov.
Parmelia baltimorensis Gyel. & Fór., Ann. Crypt. Exot. 4:167. 1931.
Pseudoparmelia baltimorensis (Gyel. & Fór.) Hale, Phytol. 28:189. 1974.

Flavoparmelia callichroa (Kurok.) Hale, comb. nov.
Pseudoparmelia callichroa Kurok. in Hale, Smith. Contr. Bot. 31:20. 1976.

Flavoparmelia caperata (L.) Hale, comb. nov.
Lichen caperatus L., Sp. Pl. 1147. 1753.
Parmelia caperata (L.) Ach., Meth. Lich. 216. 1803.
Pseudoparmelia caperata (L.) Hale, Phytol. 28:189. 1974.

Flavoparmelia euplecta (Stirton) Hale, comb. nov.
Parmelia euplecta Stirton, Scot. Nat. 4:299. 1877-78.

Flavoparmelia exornata (Zahlbr.) Hale, comb. nov.
Parmelia caperata var. exornata Zahlbr., Ann. Mycol. 10:379. 1912.
Pseudoparmelia exornata (Zahlbr.) Hale, Smith. Contr. Bot. 31:31. 1976.

Flavoparmelia ferax (Müll. Arg.) Hale, comb. nov.
Parmelia ferax Müll. Arg., Flora 69:257. 1886.
Pseudoparmelia ferax (Müll. Arg.) Hale, Phytol. 28:190. 1974.

Flavoparmelia gerlachei (Zahlbr.) Hale, comb. nov.
Parmelia antarctica Vain., Rés. Exp. Ant. Belgique, p. 13. 1903. Not P. antarctica Bitter, Hedw. 40:248. 1901 (=Hypogymnia).
Parmelia gerlachei Zahlbr., Cat. Lich. Univ. 6:137. 1929.
Pseudoparmelia gerlachei (Zahlbr.) Hale, Smith. Contr. Bot. 31:32. 1976.

Flavoparmelia haysomii (Dodge) Hale, comb. nov.
Parmelia haysomii Dodge, Nova Hedw. 15:295. 1968.

Flavoparmelia helmsii (Kurok. & Fils.) Hale, comb. nov.
Parmelia helmsii Kurok. & Fils., Austral. Journ. Bot. 30:539. 1982.

Flavoparmelia jelineckii (Krempih.) Hale, comb. nov.
Parmelia jelineckii Krempih., Verh. K.-K. Zool.-Bot. Gesell. Wien 18:321. 1868.

Flavoparmelia pachydactyla (Hale) Hale, comb. nov.
Parmelia caperata var. isidiophora Steiner, Sitz. Kaiser. Akad. Wissen. Wien 106:215. 1897.
Parmelia pachydactyla Hale, Bryol. 75:345. 1972.
Pseudoparmelia pachydactyla (Hale) Hale, Phytol. 28:191. 1974.

Flavoparmelia papillosa (Gyel.) Hale, comb. nov.
Parmelia papillosa Lynge ex Gyel., Ann. Mus. Nat. Hung. 29:43. 1935.
Pseudoparmelia papillosa (Gyel.) Hale, Smith. Contr. Bot. 31:40. 1976.

Flavoparmelia rutidota (Hook. & Tayl.) Hale, comb. nov.
Parmelia rutidota Hook. & Tayl., Hook. Lond. Journ. Bot. 3:645. 1844.
Pseudoparmelia rutidota (Hook. & Tayl.) Hale, Phytol. 28:191. 1974.

Flavoparmelia soredians (Nyl.) Hale, comb. nov.
Parmelia soredians Nyl., Flora 55:426. 1872.
Pseudoparmelia soredians (Nyl.) Hale, Phytol. 28:191. 1974.

Flavoparmelia springtonensis (Elix) Hale, comb. nov.
Parmelia springtonensis Elix in Elix & Stevens, Austral. Journ. Bot. 27:879. 1979.
Flavoparmelia subamplexa (Hale) Hale, comb. nov.
Pseudoparmelia subamplexa Hale, Smith. Contr. Bot. 31:50. 1976.

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Hale, M. E. 1976. A monograph of the lichen genus Pseudoparmelia Lynge (Parmeliaceae). Smith. Contr. Bot. 31:1-62.
Lynge, B. 1914. Die Flechten der ersten Regnellschen Expedition. Die Gattung Pseudoparmelia gen. nov. und Parmelia Ach. Arkiv f. Bot. 13(13):1-172.

MYCOTAXON

Vol. XXV, No. 2, pp. 607-620 April-June 1986

RUSSULA VESICATORIA AND RUSSULA ANGUSTISPORA SP. NOV., TWO CONFUSING SPECIES OF RUSSULA SUBSECTION LACTARIOIDEAE

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KEYWORDS: *Russulaceae, Russula, mycorrhizal associations.*

SUMMARY

Russula vesicatoria, a poorly understood species previously recorded only from Florida, occurs over a wide geographic area in *Pinus* forests of the Gulf Coast and eastern seaboard of North America. An illustrated description and new information on its habitat and geographic distribution are presented. *Russula angustispora*, a taxon that has been confused with other members of the subsection *Lactarioideae*, is described as new.

INTRODUCTION

The subsection *Lactarioideae* Maire (=subsection *Plorantes* (Bat.) Singer) is one of the best known and most distinctive groups of *Russula* species. Monographs of both North American and European species of this subsection permit identification of specimens with a high degree of confidence when the collector records the necessary macroscopic and microscopic data (Shaffer, 1964; Romagnesi, 1967). A major limitation of these works has been that most of the information included was based on specimens from western Europe and northeastern or northwestern North America.

Two taxa of the *Lactarioideae* that occur commonly and predictably in specific habitats in southeastern North America have been confused often with *R. brevipes* Peck

and its varieties and with other taxa of this subsection despite reference to available monographs. One of these species is *R. vesicatoria* Burlingham. The second species, *R. angustispora*, is described here as new. Descriptions, illustrations, and notes on habitat and geographic distributions are presented to facilitate their identification, to refine further their circumscriptions, and to clarify their relationships to other taxa of the subsection *Lactarioideae*.

Basidiospore size and shape are from optical sections in side view and exclude the ornamentation. Capitalized color names are from Ridgway (1912). Spore-print and some lamellar colors are from Romagnesi (1967). Macro- and microchemical tests were made according to the methods of Romagnesi (1967) and Singer (1975). The letters SV stand for sulfovanillin. All specimens are deposited at BPI unless stated otherwise. For scanning electron microscopy (SEM), dried pieces of mature lamellae were rehydrated overnight and then dehydrated through an ethanol series. After critical point drying, lamellar pieces were attached to aluminum stubs, coated with gold under vacuum on a rotary stage, and examined with an AMRAY 1200B scanning electron microscope.

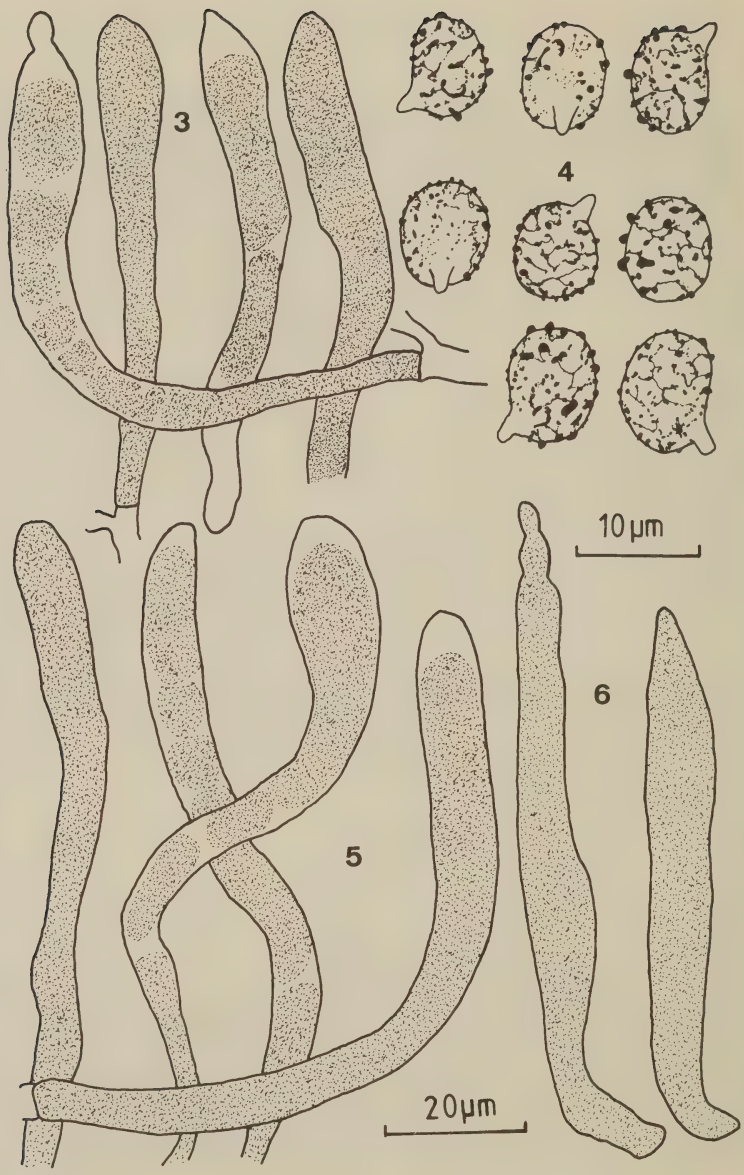
DESCRIPTIONS OF TAXA

RUSSULA VESICATORIA Burlingham, *Mycologia* 36: 118. figs. 1-t, 2. 1944.

FIGS. 1, 3-6, 11, 12

PILEUS 4-20 cm broad, pulvinate to convex-depressed with involute or incurved margin when young, soon convex-depressed to shallowly or deeply infundibuliform with margin uplifted or arched in age; margin not striate, sometimes minutely felted; cuticle inseparable; surface dull, dry, subviscid when wet, chalk-like, glabrous to minutely pruinose or velvety, often developing areolate patches, sometimes becoming concentrically areolate or lacerate, especially in dry weather, white to dingy grayish white, Cream Color, pale grayish yellow, with pale yellowish brown to light brown, Pale Pinkish Cinnamon, Light Pinkish Cinnamon or, Clay Color spots or areolate areas in age; trama hard-rigid, brittle in age, up to 12 mm thick at midradius, white to cream, yellowish brown around larval channels, unchanging when cut; odor of feungreek (*Trigonella foenum-graecum* L.) or *Lactarius camphoratus* (Bull. : Fr.) Fr. when young, mild to

FIGS. 1-2. *Russula* spp. 1. *R. vesicatoria* (GB 470), X 1/3. 2. *R. angustispora* (GB 548, HOLOTYPE), X 1/2.



FIGS. 3-6. *Russula vesicatoria* (GB 916). 3. Caulocystidia. 4. Basidiospores. 5. Dermatocystidia. 6. Hymenial cystidia.

disagreeable in age; taste acrid to bitter when young, bitter to disagreeable or mild in age. LAMELLAE adnate to decurrent, extremely crowded to close, with many lamellulae of various lengths, repeatedly forked or anastomosing, especially near the stipe, acute in front, narrow, 2-5 mm broad at midradius, easily separated from pileus trama, white to pale cream or grayish yellow, Light Buff, Pale Pinkish Buff or, Pale Pinkish Cinnamon, slowly bruising dingy yellowish brown or not, reminiscent of *L. piperatus* (L. : Fr.) S. F. Gray; edges even or minutely pruinose. STIPE 1-4 cm tall, 1-3 cm wide at midpoint, robust, tapered toward the base, with white basal mycelium, often with a mass of sand adhering to basal mycelium; surface dry, dull, smooth, concolorous with pileus; trama solid or with interior hollow in age, hard but brittle, white or stained yellowish brown at base, unchanging when cut. CHEMICAL REACTIONS (stipe trama): formalin-no reaction; gum guaiac-greenish blue; $FeSO_4$ -grayish pink to pale red; phenol-grayish maroon; aniline-lemon yellow in 5 min.

BASIDIOSPORES yellow, Light Buff (Romagnesi IIIa) in mass on paper; 6.5-8.5(-10) X 5.5-7.5(-8) µm, subglobose, broadly obovate to obovate; ornamentation amyloid, up to 0.8 µm high, mostly 0.2-0.6 µm high, consisting of relatively crowded, blunt, hemispherical to cylindrical verrucae and fine particles, with verrucae often joined by a few lines, low ridges, or short chains of fine particles, usually forming a partial to nearly complete reticulum; suprahilar area depressed, unornamented or with a few fine particles. BASIDIA narrowly clavate to clavate, 42-58 X 8-10.5 µm, 4-sterigmate. HYMENIAL CYSTIDIA 51-85 X 8-10.5 µm, projecting up to 25 µm beyond basidia, narrowly clavate, cylindrical, subulate, or ventricose-rostrate, with rounded, acuminate, submoniliform, or attenuated apices, arising from trama, subhymenium, or hymenium, partially or completely filled with hyaline to pale yellow, refractive contents in KOH, grayish yellow to grayish yellow-green in SV. SUBHYMENIUM up to 35 µm thick, often poorly developed or absent, pseudoparenchymatous to interwoven. LAMELLAR TRAMA composed of sphaerocysts, interwoven connective hyphae, laticifers, and pseudoparenchyma, entirely of pseudoparenchyma and interwoven hyphae towards distal end.

PILEUS CUTICLE 225-550 µm thick, without gelatinous materials, a relatively undifferentiated cutis, composed of interwoven, horizontal to ascending hyphae, dermatocystidia, and laticifers; cuticular hyphae 3-6.5 µm

in diam, septate, branched, often arranged in ascending to erect, tangled fascicles or aggregates at the pileus surface; dermatocystidia 80-300+ X 6.5-12 µm, cylindrical to clavate, curved or flexuous, usually aseptate, rarely 1-septate, arising from the laticiferous hyphal system, partially or completely filled with hyaline to pale yellow refractive contents in KOH, grayish yellow to greenish yellow-gray in SV. PILEUS TRAMA consisting of sphaerocysts, connective hyphae, and abundant laticifers; laticifers 5-10.5 µm in diam, straight to flexuous, with refractive hyaline to pale contents in KOH, grayish yellow in SV.

STIPE CUTICLE 250-500 µm thick, similar to pileus cuticle, without gelatinous materials, one-layered, composed of horizontal to ascending hyphae, laticifers, and caulocystidia; hyphae 3-6.5 µm in diam, septate, branched or not, sometimes with constricted, attenuated, or slightly inflated apices; often aggregated into ascending or erect fascicles at the surface; caulocystidia 45-300+ X 7.5-12 µm, cylindrical to clavate, with rounded, acuminate, or rarely submoniliform apices, arising from the trama or connective hyphae. STIPE TRAMA composed of connective hyphae, nests of sphaerocysts, and laticifers. CLAMP CONNECTIONS absent from all tissues.

HABIT, HABITAT, AND DISTRIBUTION. Gregarious on sand or sandy soil under 2-3 needle pines, e.g. *Pinus taeda* L., *P. australis* Michx., *P. rigida* Mill., *P. virginiana* Mill., and probably other southern *Pinus* species. Known from coastal regions of eastern North America from Mississippi to southern New Jersey.

MATERIAL EXAMINED: USA: FLORIDA: Alachua Co.: Gainesville, 18 May 1948, R. Singer F1918a, 28 Jun 1943, R. Singer F2404 (both FH), G. Bills, 10 Aug 1985; Seminole Co.: Lake Wildmere, Longwood, G. S. Burlingham, 23 Oct 1941 (HOLOTYPE, NY), 21 Oct 1941 (labeled Co-type, NY) and 6 additional collections (NY). MARYLAND: Anne Arundel Co.: Ft. Meade Golf Course, 7 Oct 1971, K. H. McKnight 12792A; Charles Co.: Cedarville State Park, 19 Jul 1973, K. H. McKnight 13696; Prince George's Co.: Greenbelt Park, 4 Sep 1981, M. Farr & C. Fritz, Greenbelt, 14-15 Aug 1977, D. Farr 2450 & 2451, Laurel, Pfister's Woods, 23 Jul 1967, J. Lindsay 50 (VPI), 6 Sep 1967, O. K. Miller 6085 (VPI), Laurel, Fox Rest Woods, 13 Aug 1967, J. Lindsay 122 (VPI), Laurel, Forest Disease Lab, 11 Aug 1965, O. K. Miller 3240 (VPI), 22 Sep 1965, O. K. Miller 3677 (VPI), Beltsville,

BARC-West, Wagstaff, 15-16 Sep 1974. MISSISSIPPI: Saucier Co.: Harrison Experimental Station, 26 Jul 1983, C. Ovrebo 1544 (MICH). NEW JERSEY: Burlington Co.: Lebanon State Forest, 1 Sep 1984, GB 916. SOUTH CAROLINA: Jasper Co.: along I-95, 9 Aug 1985, G. Bills & R. Vilgalys. VIRGINIA: James City Co.: York River State Park, 14 Aug 1983, GB 470.

DISCUSSION. Prior to this report, the geographic distribution of *R. vesicatoria* has been documented accurately only in Florida by Burlingham (1944) and Singer (1957). Burlingham (1944) also mentioned H. C. Beardslee's observation of this species along the coast of North Carolina. Singer (1957) described western collections of "*R. vesicatoria*" which were later described as a new species, *R. cascadensis* Shaffer (Shaffer, 1964). Miller (1973) noted that *R. vesicatoria* occurred in Maryland and Virginia, but examination of his specimens indicated his concept was based on a mixture of *R. vesicatoria* and *R. angustispora* Bills (see next description).

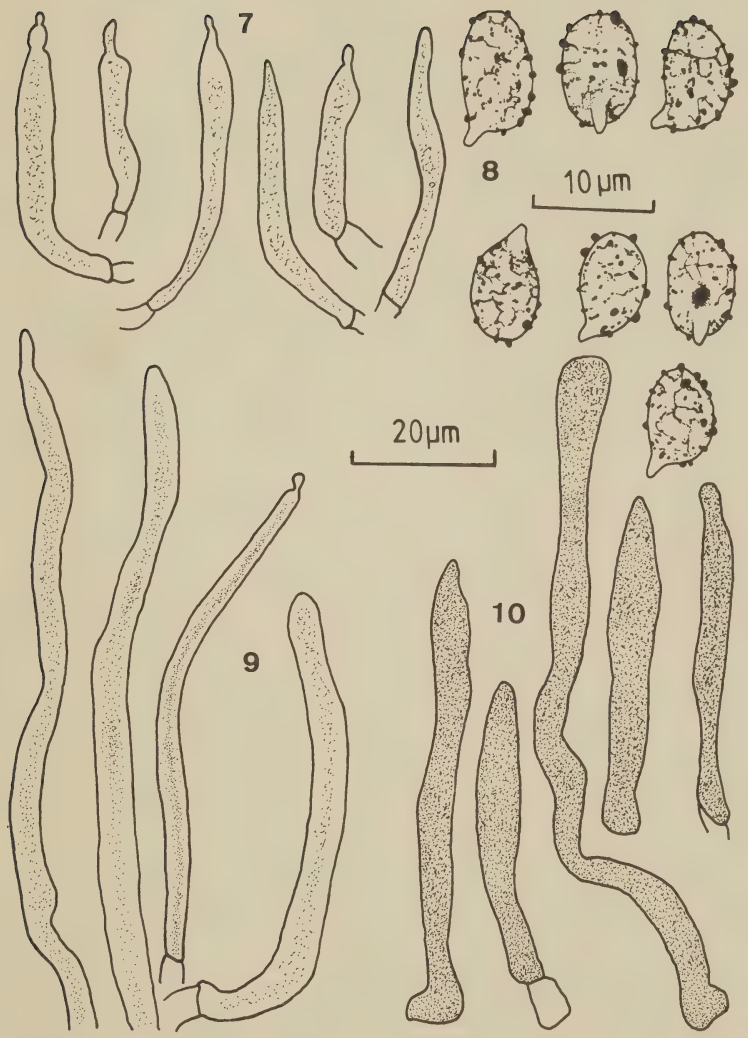
Russula vesicatoria is one of the most distinctive species of the subsection *Lactarioideae*. In the field, it can be recognized by its crowded, narrow lamellae that resemble those of *L. piperatus*, the relatively large sporocarps, and the habitat in sandy *Pinus* forests. Also the pileus surface is unusually dull and opaque and tends to crack concentrically in dry weather. Shaffer (1964) used the acrid taste and odor of *L. camphoratus* (as recorded by Burlingham) to separate *R. vesicatoria* from other taxa of subsection *Lactarioideae* with low basidiospore ornamentation. The taste and odor of *R. vesicatoria* seem to be age-dependent and therefore inconsistent characters. Old sporocarps usually lack the acrid taste and *L. camphoratus* odor but retain the bitter taste component. The abundant, weakly SV+, large dermatocystidia and laticifers of the pileus and stipe surface and the broad basidiospores with relatively low ornamentation also distinguish *R. vesicatoria* from similar taxa.

RUSSULA ANGUSTISPORA Bills, sp. nov.
FIGS. 2, 7-10, 13, 14

Sporocarpis parvis *Russulae brevipedis* similis. Pilei maturi quum plano-depressi tum infundibuliformes; superficies arida, alba primum deinde avellanea; trama

juventute dura, immutata ubi scissa; odor indistinctus; sapor mitis vel parum ingratus aut acridus. Lamellae multis lamellulis instructae, quum confertae tum parum remotae, luteolae ubi maturae, nullo modo viridae. Stipes brevis, aequalis aur deorsum decrescens; superficies alba; trama armeniaca in salibus ferri. Basidiospores citrae ubi confertae, 6.5-8.5 X 4.5-6 µm, angustae, quum ellipticae tum late ellipticae, ornamentum pro parte maxima 0.2-0.6 µm altum, verrucis particulisque plerumque segregatis. Cystidia hymenialia plerumque 29-85 X 4-8 µm, gracilia, in hymenia inclusa. Cuticula pilei stratum crassitudine inconstans, hyphis horizontalibus intertextis compositum, paucis dermatocystidiis; hyphae cuticulares interdum parietibus asperis, refringentibus, aut parum incrassatis instructae. Sub *Pinum virginianum* autumno sero fructificans. Holotypus ab Estes' Farm, Blacksburg, Montgomery Co., Virginia, 20 Nov 1982, G. Bills 548 (BPI).

PILEUS 2-7.5(-9) cm broad, pulvinate to convex-depressed with involute or incurved margin when young, soon plano-depressed with incurved or arched margin, finally shallowly to deeply infundibuliform with margin arched or uplifted, sometimes slightly eccentric, occasionally perforated through the disc in age; margin not striate; cuticle separable one-half to two-thirds way to the disc; surface dull, mat, dry or rarely moist, minutely rugulose to smooth, minutely velvety, especially over the disc, initially white, soon developing cream, Cream Color, grayish yellow, grayish buff, or yellowish brown blotches or streaks, often becoming entirely grayish yellow, yellowish brown, or pale brown, Clay Color in age; trama hard when young, soon elastic to brittle, up to 9 mm thick at midradius, white to pale buff, yellowish brown around larval channels, unchanging when cut; odor not distinct; taste mild, fungoid (like *Agaricus campestris* Fr.), occasionally bitter, or with a disagreeable or slightly acrid aftertaste. LAMELLAE subdecurrent to decurrent, close to medium spaced, with many lamellulae of various lengths, often forked or anastomosing, intervenose, subacute in front, up to 5 mm broad at midradius, white when young, soon pale yellow (Romagnesi Ib-IIc), without green coloration; edges even, often developing yellowish brown to brown stains in age, white to dingy yellowish gray, unchanging when cut. STIPE 1.5-4 cm tall, 1-2 cm wide at midpoint, equal or tapered toward the base, with sparse white basal mycelium; surface dull, dry, glabrous, minutely or longitudinally rugulose,



FIGS. 7-10. *Russula angustispora* (GB 548, HOLOTYPE). 7. Cystidia from surface of mycorrhizal mantle of *R. angustispora* + *Pinus virginiaina*. 8. Basidiospores. 9. Dermatocystidia. 10. Hymenial cystidia.

white to dingy yellow or yellowish brown in age, white to dingy yellowish gray, unchanging when cut. CHEMICAL REACTIONS (stipe trama): formalin-no reaction; gum guaiac-greenish blue; $FeSO_4$-pinkish orange; phenol-dull grayish maroon to pinkish maroon; aniline (lamellae)-yellow in 5-10 min.

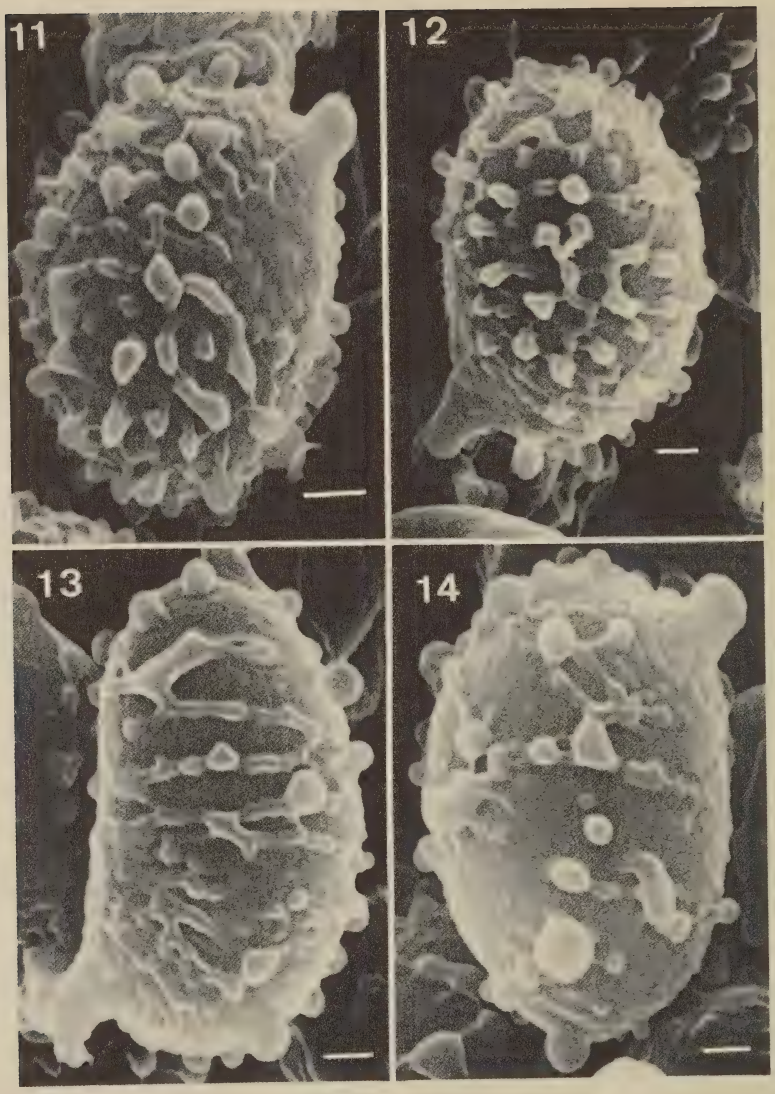
BASIDIOSPORES yellow (Romagnesi IIb-IIc) in mass on glass, (6-)6.5-8.5(-9) X 4.5-5 µm, elliptical, broadly elliptical, ovate, or rarely obovate; ornamentation partially to completely amyloid, up to 1 µm high, mostly 0.2-0.6 µm high, consisting of subglobose, hemispherical, or cylindrical verrucae, and many fine particles, with a few low lines connecting two or three verrucae or particles, sometimes verrucae or particles fused to form short ridges, forming a partial reticulum at most; suprahilar area slightly depressed or not, usually unornamented, occasionally with a few scattered particles or a low irregular, weakly amyloid patch. BASIDIA 38-50 X 7.5-10.5 µm, clavate to narrowly clavate, 4-sterigmate. HYMENIAL CYSTIDIA 29-85(-120) X 4-8 µm, narrowly clavate, cylindrical, subulate, or ventricose-rostrate, with rounded, acuminate, or submoniliform apices, often curved or flexuous basally, embedded to projecting up 10 µm beyond the basidia, arising from the hymenium, subhymenium, or trama, with weakly to strongly refractive hyaline to pale yellow contents in KOH, greenish purple, grayish purple to blackish purple in SV. SUBHYMENIUM 10-25 µm thick, pseudoparenchymatous. LAMELLAR TRAMA composed of sphaerocysts, connective hyphae, and a few scattered laticifers. PILEUS CUTICLE 95-280 µm thick, without gelatinous materials, a thin to relatively thick layer of interwoven, horizontal hyphae, with rare to scattered dermatocystidia, and scattered laticifers near the pileus trama, with outer hyphae appressed to the surface or ascending, often arranged in parallel strands; cuticular hyphae septate, branched, filamentous or irregularly inflated, 2-8 µm in diam, with round apices, inflated cells up to 15 µm in diam; hyphal walls thin, refringent, or slightly thickened, often irregularly thickened or roughened in outline; dermatocystidia 25-200 X 3-8 µm, cylindrical, with apices rounded, acuminate, or submoniliform, 0-1 septate, partially filled with weakly refractive contents, hyaline in KOH, pale gray to pale purplish gray in SV, arising from cuticular hyphae and laticifers. PILEUS TRAMA consisting of nest of sphaerocysts, connective hyphae, and laticifers; laticifers flexuous, septate, 4-8 µm in diam, with

refractive contents, hyaline in KOH, pale purplish gray, greenish purple, or grayish purple in SV. STIPE CUTICLE 15-90 µm thick, without gelatinous materials, consisting of a thin layer of interwoven, horizontal to ascending hyphae and laticifers; surface hyphae often aggregated in parallel strands; cuticular hyphae 2-6 µm in diam, similar to hyphae of pileus cuticle; laticifers 4-6 µm in diam, abundant, with refractive contents, hyaline in KOH, grayish yellow greenish yellow-gray in SV. STIPE TRAMA consisting of nests of sphaerocysts, connective hyphae, and scattered laticifers. CLAMP CONNECTIONS absent from all tissues.

HABIT, HABITAT, AND DISTRIBUTION. Scattered to gregarious on soil or erumpent through needle duff in pure stands of *Pinus virginiana* or mixed stands of *P. virginiana* and hardwoods from late September to December. Presently known from southeastern Maryland to southwestern Virginia, but possibly associated with *P. virginiana* throughout its geographic range.

MATERIAL EXAMINED. USA: MARYLAND: Prince George's Co.: Kettle Run, Occoquan Creek, 11 Nov 1969, K. H. McKnight 11669, Laurel, Forest Disease Lab, 4 Nov 1966, K. H. McKnight 10086, O. K. Miller 4962 & 4963 (VPI). VIRGINIA: Albemarle Co.: Ivy Creek Natural Area, near Charlottesville, 20 Oct 1984, GB 937; Highland Co.: Headwaters, along U.S. 250, 28 Oct 1984, GB 942; Montgomery Co.: near Christiansburg, Rt. 604, 1 Nov 1984, GB 946, Luster's Gate, 28 Nov 1982, GB 557 (coll. R. Vilgalys), Blacksburg, Estes' Farm, 20 Nov 1982, GB 548 (HOLOTYPE, BPI, ISOTYPE, MICH), Blacksburg airport, S. Miller 653 (pers. herb.), Price's Fork Rd., 6 Nov 1984, GB 948.

DISCUSSION. Efforts to determine this taxon using the keys of Shaffer (1964) have proven unsuccessful. Although *R. angustispora* could be confused macroscopically with several taxa of the subsection *Lactarioideae*, the relatively short, narrow, elliptical basidiospores with coarse, blunt, predominately isolated ornamentation are unlike those of any of the taxa treated by Shaffer (1964) or Romagnesi (1967). Spore ornamentation within a single specimen is highly variable, ranging from densely spaced, interconnected verrucae that form a partial reticulum (Fig. 13) to irregularly spaced, isolated verrucae (Fig. 14). In addition to the characteristic basidiospore shape



FIGS. 11-14. Basidiospores of *Russula* spp. (SEM) (standard bar=1 µm). 11. *R. vesicatoria* (GB 916). 12. *R. vesicatoria* (GB 916). 13. *R. angustispora* (GB 548, HOLOTYPE), basidiospore with predominately reticulate ornamentation. 14. *R. angustispora* (GB 548, HOLOTYPE), basidiospore with predominately isolated ornamentation.

and ornamentation, the roughened, slightly thickened or refringent walls of the pileus-cuticle hyphae, and the late-autumn, *Pinus*-associated habitat distinguish *R. angustispora* from similar taxa, e.g. the varieties of *R. brevipes*, *R. inopina* Shaffer, and *R. romagnesiana* Shaffer. Because *R. brevipes* also occurs in these habitats (usually earlier in the season), the spore deposit colors and the microscopic features of the two taxa should always be compared.

Russula angustispora is a constant component of the late-autumn agaric flora of second-growth *P. virginiana* stands and appears to be restricted to these habitats. Ectomycorrhiza formation by *R. angustispora* and *P. virginiana* has been confirmed experimentally (S. Miller and P. Dery, unpublished data). A striking feature of the ectomycorrhizal mantle formed by *R. angustispora* + *P. virginiana* is the abundant cystidia arising from a laticiferous hyphal system on the mantle surface (Fig. 7). These cystidia are similar in morphology and contents to those of the pileus and stipe surface.

ACKNOWLEDGMENTS

Portions of this study were supported by a grant from the Jeffress Mermorial Trust to Dr. O. K. Miller, Jr., V.P.I. & S.U., and a Gertrude S. Burlingham Fellowship from the New York Botanical Garden to the author. Dr. R. L. Shaffer provided critical information on taxa of *Russula* subsection *Lactarioideae*. The loan of specimens is acknowledged from the following herbaria, their curators, and their staffs: BPI, FH, MICH, NY, and VPI. Mr. J. Plaskowitz guided the preparation and photography of materials for SEM. Professor T. MacAdoo of the Foreign Languages Department, V.P.I. & S.U., kindly prepared the Latin diagnosis. Special thanks to Dr. M. E. Palm for her critical reading of the manuscript.

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MYCOTAXON

Vol. XXV, No. 2, pp. 621-628 April-June 1986

ACAULOSPORA DELICATA SP. NOV. — AN ENDOMYCORRHIZAL FUNGUS FROM ARIZONA*

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SUMMARY

A newly discovered endomycorrhizal fungus, *Acaulospora delicata,* which forms typical vesicular-arbuscular mycorrhizas with Sudan grass and sorghum, is described and illustrated.

INTRODUCTION

Sand from a greenhouse bed, used for the propagation of cuttings of various ornamental plants, was wet-sieved and the resultant sievings centrifuged in sugar solution (Walker, Mize & McNabb 1982) in order to extract endogonaceous spores. After spores had been extracted, they were suspended in water and observed under a dissecting microscope. Among the spore types present was one we did not recognise. Spores of this type were separated and a representative sample studied on slide mounts under a compound microscope. All these spores proved to be morphologically similar and unlike any described species. We then selected more of these spores and added them to pots of sterilised sand sown with seeds of *Sorghum vulgare* Pers. (sorghum), *S. sudanense* (Piper) Staph. (Sudan grass) and *Lolium perenne* L. (perennial rye grass) in attempts to produce pure pot cultures. These cultures were maintained in a growth chamber with a diurnal temperature range of 15°C to 27°C and illuminated for a 16 hour photoperiod with a mixture of fluorescent and incandescent light.

The plants and their potting medium were examined after 90 days for the presence of mycorrhizas and spores. Perennial ryegrass proved to be ineffective as a host. Vesicular-arbuscular mycorrhizas were observed in the *Sorghum* spp. after clearing and staining the roots (Phillips & Hayman 1970), and abundant spores, all of similar morphology were extracted. The spores were formed laterally on the neck of a sporiferous saccule (Walker, Reed & Sanders 1984), a characteristic of the genus

*Scientific paper Number 4143, Arizona Agriculture Experiment Station, Tucson, Arizona, USA 85721.

Acaulospora Gerd. & Trappe, but were different from those of any other described species in the genus (Gerdemann & Trappe 1974, Trappe 1982, Trappe & Schenck 1982, Schenck *et al* 1984).

The description of wall structures and the murographs (Fig. 1) follow the standardized terminology of Walker (1983). The species description is made from specimens mounted on microscope slides in distilled water or in polyvinyl alcohol lactophenol (PVL), to which stains and reagents had been added as required.

ACAULOSPORA DELICATA Walker, Pfeiffer & Bloss sp. nov. (Fig. 1-3)

Sporae singillatim in terra vel intra radicellas senescentes enatae, lateraliter gestae in sacculo sporifero hyalino 60-95 x 70-125 μm, hyalinae vel flavo-eburneae, ob sporae contentis scintillantes, globosae, subglobosae vel raro ovoideae vel obovoideae, 80-125(-150) x 80-110 (-140) μm. Sporarum tunicae 3-4 in turmis duabus: Turma A cum tunicae hyalinae extimae evanescenti ca. 1 μm crassae (Tunica 1), ad Tunicam 2 adhaerenti; Tunica 2, 2.5-3.5 μm crassa, laminata. Tunicae Turma B cum tunicarum una vel duabus (Tunicae 3 et 4), unaquaeque tenuis, hyalina, membranaceaque. Tunica 3 minute granulosa. Tunicae membranaceae in solutioni Melzeri cinnabarinae.

SPORES borne singly in the soil laterally on the neck of a sporiferous saccule; hyaline to pale yellowish-cream, sparkling from the nature of the spore contents; globose to subglobose (rarely ovoid to obovoid), 80-125(-150) x 80-110(-140) μm. Occasionally spores occurring in the cortical cells of senescent roots (Fig. 3C).

SPORIFEROUS SACCULE (Fig. 2A) usually broader than long, 60-95 x 70-125 μm, hyaline, consisting of the swollen tip of a thin-walled coenocytic hypha, 10-12.5 μm diam, with a single wall 1-2 μm thick. Soil particles and debris often adhering to the exterior of collapsed saccules.

SPORE WALL STRUCTURE of four walls (Walls 1-4) in two groups (Group A and Group B). (See Murograph, Fig. 1A).

WALL GROUP A consisting of a thin, hyaline, outer evanescent wall (Wall 1) approximately 1 μm thick before disintegration, closely attached to Wall 2 which is a relatively thick (2.5-3.5 μm) laminated wall with up to 6 subequal laminations that often are very difficult to observe. Soil particles and debris often adherent to the evanescent outer wall (Wall 1) (Fig. 2C).

WALL GROUP B of two thin, hyaline, membranous walls (Walls 3 & 4), ± 0.5 μm and 0.75-1 μm thick respectively. Wall 3 covered by minute granular excrescences that become increasingly crowded with age and that are difficult to see under the light microscope, but which can be observed readily with the aid of a scanning electron microscope (Fig. 3A, 3B). Membranous walls rapidly turning orange-red in Melzer's reagent. Wall 1 not reacting in this reagent; Wall 2 deepening in colour to become a slightly darker yellow.

ETYMOLOGY: Latin — *delicata,* referring to the rather fragile nature of the spores due to their thin walls.

MYCORRHIZAL ASSOCIATIONS: The species forms typical vesicular-arbuscular mycorrhizas with *Sorghum sudanense* and *S. vulgare* (Fig. 3D).

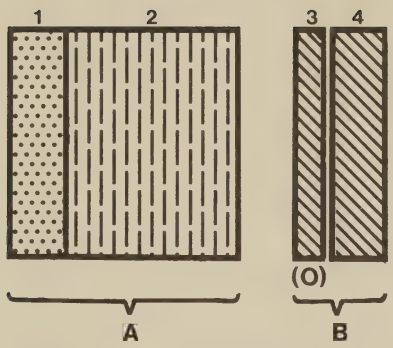

Fig. 1A: *Acaulospora delicata*

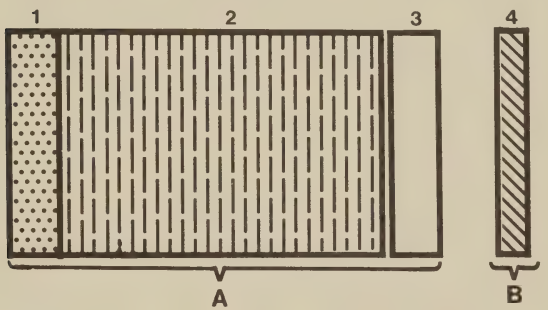

Fig. 1B: *Acaulospora nicolsonii*

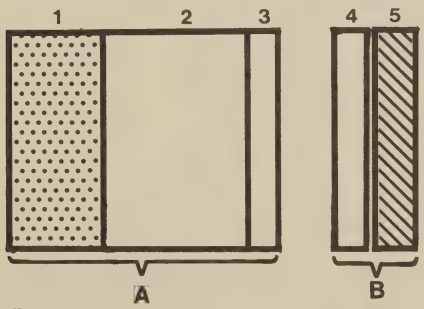

Fig. 1C: *Acaulospora longula*

Fig. 1 Murographs (after Walker 1983) of *Acaulospora delicata* (Fig. 1A) and two superficially similar species, *A. nicolsonii* (Fig. 1B) and *A. longula* (Fig. 1C). Evanescent walls are shaded with dots, laminated walls with broken lines, membranous walls with diagonal lines, and unit walls are left unshaded. Wall 3 is ornamented, but the ornamentation is often difficult, and sometimes impossible, to observe with a light microscope.

COLLECTIONS EXAMINED

Holotype: ARIZONA - Pima County, Tucson; from a pot culture with S. *sudanense* (OSC, isotype ARIZ, K). The origin of the sand in the green house at the University of Arizona (Building 42-2R) from which the original spores were extracted is unknown.

DISCUSSION

Spores of *Acaulospora delicata* bear a superficial resemblance to those of *A. trappei* Ames & Linderman, *A. nicolsonii* Walker, Reed & Sanders, and *A. longula* Spain & Schenck, but there are differences in the size range and colour of the spores, and in the spore wall structure of the species. The size range of spores of *A. trappei* and *A. delicata* over-lap slightly 42-99 x 42-70 μm in the former compared with 80-150 x 80-140 μm in the latter) but, in general, spores of *A. trappei* are much smaller than those of *A. delicata. A. trappei* is described as having only a single wall, whereas *A. delicata* has a complex wall structure of three or four walls in two groups. There is considerable overlap in the size range of mature spores of *A. nicolsonii,* which are 99-198 X 109-218 μm, and those of *A. delicata,* though most spores of the former are larger than most of the latter. However, the differences in wall structure between these two species is clear, and is illustrated in the murographs (Fig. 1). Wall 1 of both species is evanescent, hyaline, and approximately 1 μm thick, but although Wall 2 is laminated and may be pale yellow in both species, in *A. nicolsonii* the laminae are thicker and much easier to see than in *A. delicata* and the surface of the former fractures to form fissures at maturity, whilst in the latter it remains smooth. Wall 2 is also much thicker in *A. nicolsonii* (3-10 μm) than in *A. delicata* (2.5-3.5 μm). Wall 3 in *A. delicata* is an ornamented, membranous wall in Wall Group B; whereas in *A. nicolsonii* it is a thin, brittle, unit wall in Group A. Occasionally, the inner lamina of Wall 2 in *A. delicata* becomes partially detached and could be mistaken for a separate unit wall, but examination of a number of specimens should resolve the real nature of this artefact. Wall Group B differs between the species. Mature spores of *A. delicata* have two membranous walls one of which becomes increasingly ornamented with age (Fig. 1A); whereas *A. nicolsonii* has only one membranous wall in this group which is

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Fig. 2 Light photomicrographs of spores of *Acaulospora delicata.*

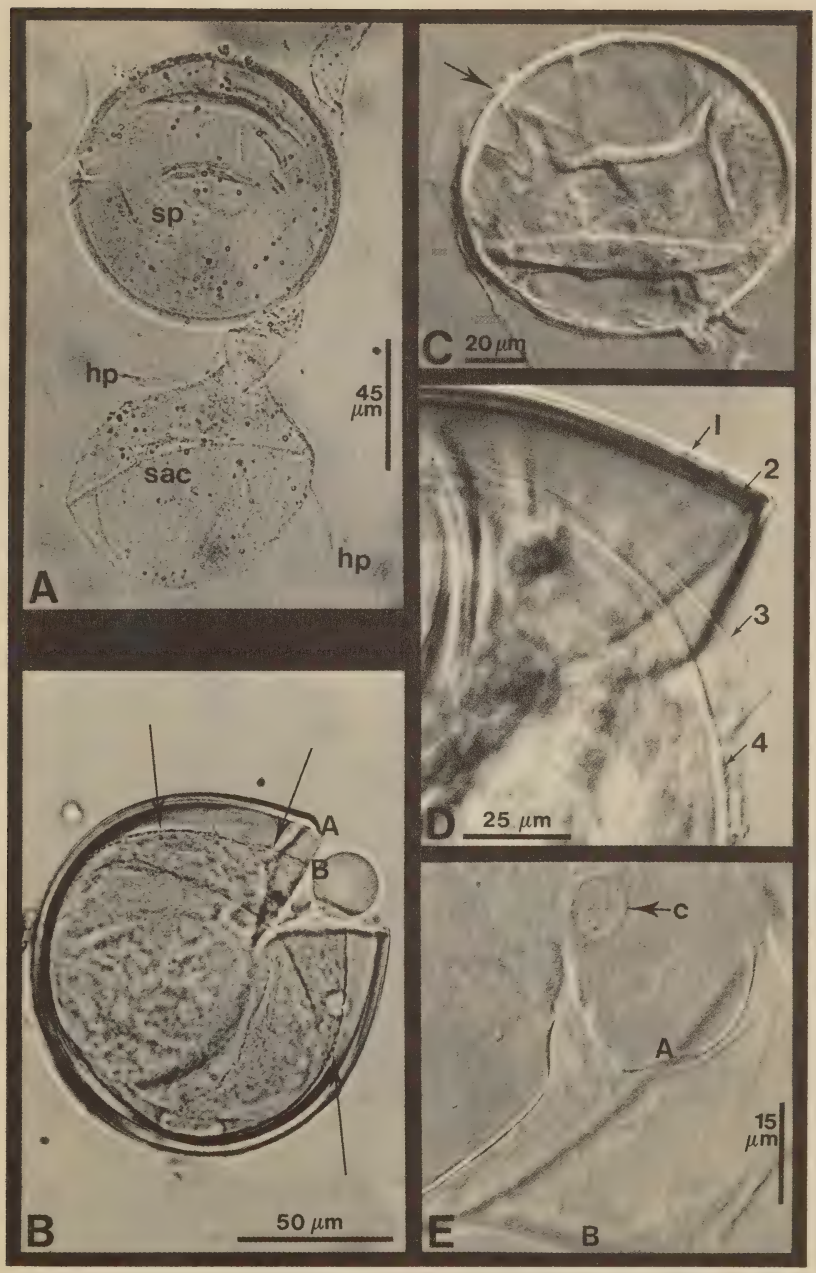
A. Sporiferous saccule (sac) with a fully-formed spore (sp) still attached. The saccule has two of the hyphal protuberances (hp) typical of the genus *Acaulospora.*

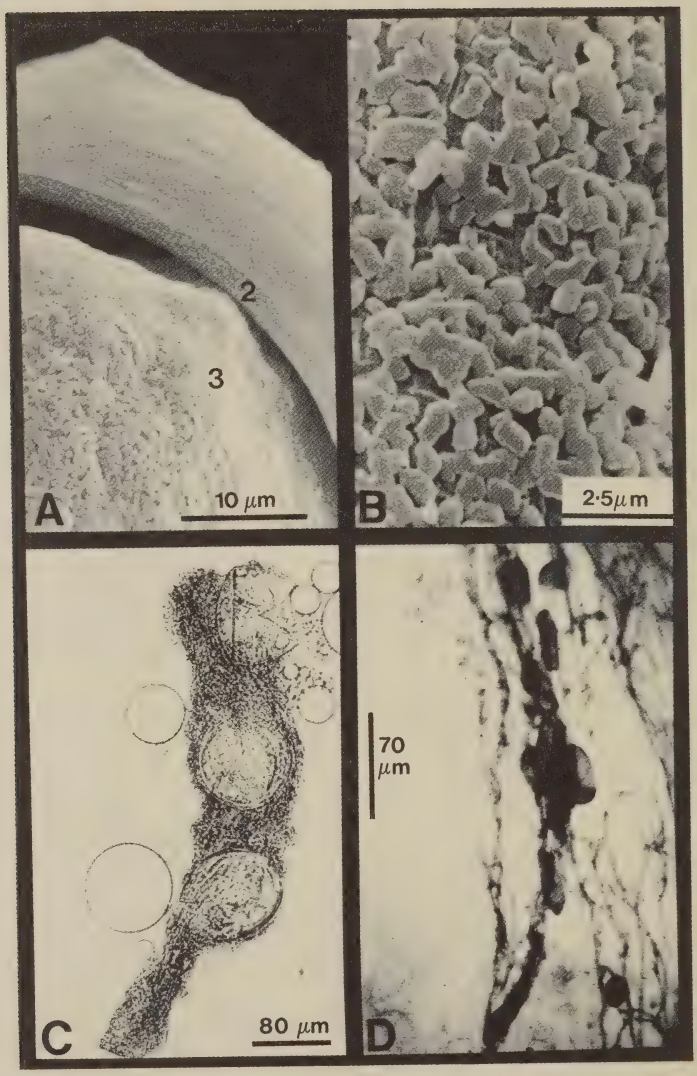
B. A fractured spore, showing the two wall groups (A and B). The ornamentation on wall 3 gives the outer surface of wall group B a finely granular appearance (arrowed).

C. A whole spore mounted in polyvinyl alcohol lactophenol to show the wrinkling of the membranous inner wall group and the debris which typically is adherent to the outer wall (arrowed).

D. In this fractured spore, all four walls (numbered as in the description and murograph) can be seen, though the ornamentation on wall 3 is not evident in this specimen.

E. Surface view of a fractured spore, showing the collar (c) formed in the outer wall group at the point of detachment from the sporiferous saccule. The two wall groups are lettered appropriately (A and B).


sp
hp
sac
hp
45 µm
A
C
20 µm
1
2
3
4
D
25 µm
A
B
B
50 µm
c
A
15 µm
E
B


2
3
10 μm
A
2·5μm
B
80 μm
C
70
μm
D

unadorned (Fig. 1B). Young spores of the former species could be confused with those of the latter, as they may seem to have only a single membranous wall with slight or no ornamentation.

Acaulospora longula spores are similar in size and colour to those of *A. delicata,* but the former has five walls and no ornamented wall in the inner wall group whereas the latter has only four walls, and has ornamentations on Wall 3 in Wall Group B (though this ornamentation may be absent in some specimens (Fig. 2D)). In addition, spores of *A. longula* are formed at distance of 100-200 μm from the sporiferous saccule, whereas spores of *A. delicata* are formed close to the base of the saccule (within 100 μm).

All other described members of the genus *Acaulospora* have either ornamented outer walls or have more deeply coloured spores (brown or yellow), and would be unlikely to be confused with *A. delicata.*

ACKNOWLEDGEMENTS

We wish to thank Dr J. M. Trappe U.S.D.A., Forest Service, Corvallis, Oregon for preparing the latin diagnosis and for his helpful review of the manuscript. We also acknowledge, with thanks, the assistance of Annelise Green, Forestry Commission, in preparation of the figures.

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Fig. 3 *Acaulospora delicata* spores and root-colonization.

A. Scanning electron micrograph (SEM) showing the laminated nature of wall 2 and the ornamentation on wall 3. Wall 1 has broken down and disappeared.

B. Detail of the ornamentation on wall 3 (SEM).

C. Spores formed in a senescent root from a pot culture with *Sorghum sudanense* (brightfield light microscopy).

D. Vesicles and intercellular hyphae of *A. delicata* in the roots of *S. sudanense* stained in cotton blue (brightfield light microscopy).

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MYCOTAXON

Vol. XXV, No. 2, pp. 629-637 April-June 1986

BOTRYOHYPOXYLON GEN. NOV. AND ITS ANAMORPH, ILEDON GEN. NOV.

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SUMMARY

Botryohypoxylon amazonense gen. et sp. nov. (Botryosphaeriaceae) and its anamorph, Iledon versicolor gen. et sp. nov. are described from dead trees in amazonian Venezuela. Botryohypoxylon is apparently unique among loculoascomycetes in having dark unicellular ascospores with an inconspicuous elongated germination site.

INTRODUCTION

In 1984 the senior author collected an ascomycete on newly dead trees in amazonian Venezuela. Perithecia were superficially similar to those of the sordariaceous genera Bombardia (Fr.) Karst. and Bombardioidea C. Moreau ex Lundqvist (Lundqvist 1972). The asci of this fungus, however, are bitunicate. For the following reasons, we conclude that this species represents an undescribed genus of the Pleosporales, Botryosphaeriacae: 1) ascomata form on a massive, erumpent stroma and are accompanied by 'eustromatic' (sensu Sutton 1980) pycnidia with apparent phialides; 2) ascospores are unicellular; 3) asci are clavate and short-stipitate with a thin ectotunica and a thick endotunica (see Eriksson 1981); 4) the hamathecium (Eriksson 1981) comprises rather wide and branched pseudoparaphyses; they lack free ends; the periphyses lining the ostiolar canal are unusual in the Botryosphaeriaceae but are found in other genera of the Pleosporales (e.g. Cucurbitaria berberidis Persoon, see Parguey-Leduc 1966); and 5) the habit is lignicolous and possibly parasitic. Botryohypoxylon amazonense Samuels & Rogers, gen. et sp. nov., is proposed below.

Botryohypoxylon is unusual among the bitunicate ascomycetes in having dark unicellular ascospores with what we interpret as an inconspicuous elongated germination site. The only species known to us that have somewhat similar characters are Semidelitschia agasmatica Cain & Luck-Allen (Cain & Luck-Allen 1969) and Loculohypoxylon grandineum (Berk. & Rav.) Barr (Barr 1976). Semidelitschia

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agasmatica is coprophilous; its ascomata are ascostromata and its ascospores are surrounded by a gelatinous sheath and have conspicuous germ slits. Ascomata of Loculohypoxylon grandineum are also ascostromata; ascomatal anatomy of this species is very different from that of Botryohypoxylon amazonense and the ascospores have true germ slits. No anamorph has been linked to either S. agasmatica or L. grandineum. These two species are not closely related to each other; neither is closely related to B. amazonense.

The apparent germination site on the ascospore of Botryohypoxylon amazonense is enigmatic. While it appears to be an ill-defined slit resembling those of the Xylariaceae (Beckett 1976 a, b) using brightfield light microscopy, transmission electron microscopy (TEM) does not reveal a break in the inner pigmented wall layers such as seen in Daldinia concentrica (Bolt.: Fr.) Ces. & de Not. (Beckett 1976 a, b). Numerous spores were seen by TEM to have a bulge on the wall which might represent a germination site and that correlates with a lighter colored region visible by light microscopy. However, by scanning electron microscopy (SEM) one sees only obvious invaginations and bulges were not seen. The germ slit of the dormant ascospore of D. concentrica appears, by light microscopy, to be a light colored slit. By SEM this light colored line is actually seen to be a slightly raised fissure covered by the outer wall layer. As germination progresses the spore swells thus causing the rupture of the outer wall layers. At no time is invagination of the wall seen. Instead, the germ fissure continues to widen as the germ tube emerges through it. The invagination on the ascospores of Botryohypoxylon amazonense is an artifact of preparation for SEM, probably a collapsed area in a weak part of the wall--the bulge visible with TEM where germination occurs. Germination of ascospores of two collections of this species was lateral, thus supporting the notion that the light-colored stripe or slit visible by brightfield microscopy is a germination site.

Ascospores of B. amazonense germinated readily on cornmeal agar (Difco) at ca. 20° C. Pycnidia that formed in cultures were morphologically similar to those found in nature but the only pycnidia found in nature were immature or were overmature and devoid of contents. Because of the strong morphological resemblance between pycnidia formed in culture and those formed in nature we believe that the pycnidia from culture do not differ significantly from those from nature and have thus based our description of this anamorph on pycnidia formed in agar culture. The anamorph of Botryohypoxylon amazonense has not previously been described and we propose below Iledon versicolor gen. et sp. nov. Because of its eustromatic pycnidia and phialidic conidiogenesis, the closest morophological comparison is with Macrophomopsis Petrak (see Sutton 1980). Pennycook & Samuels (1985) observed phialidic conidiogenesis in the anamorph of Botryosphaeria dothidea (Moug.: Fr.) Ces. & de Not. and regarded Macrophomopsis as a synonym of Fusicoccum Corda, an anamorph genus that is linked to Botryosphaeria Ces. & de Not. Conidia of Fusicoccum are unicellular and colorless; they are much larger than those of I. versicolor.

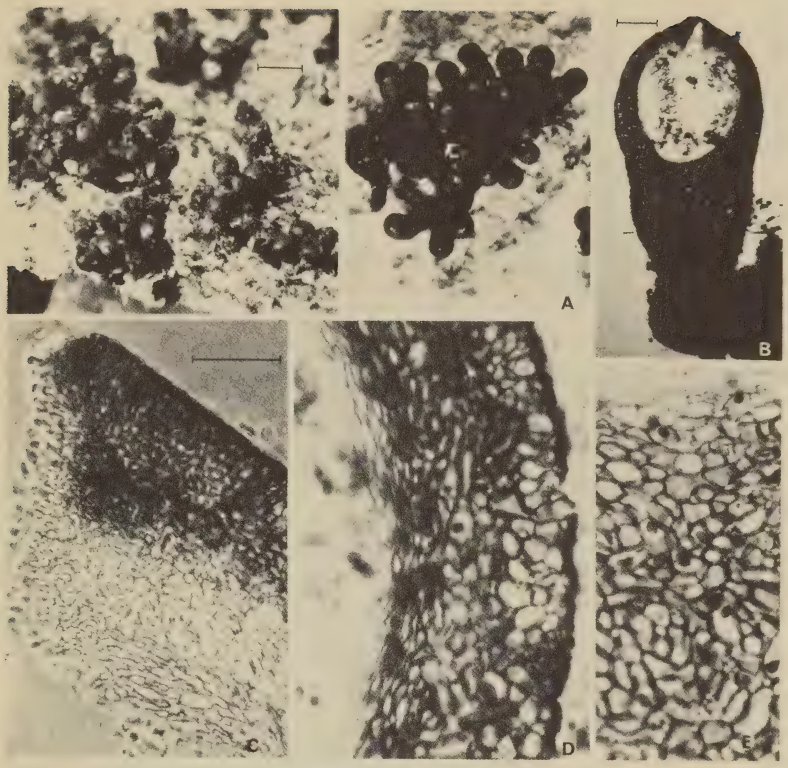

Fig. 1 Botryohypoxylon amazonense A: Ascomata. B: Median longitudinal section through a mature ascoma. C: Ascomatal apex with ostiolar canal and periphyses. D: Lateral wall of ascoma. E: Stroma immediately below ascomatal locule. (Lines: A = 1 mm, B = 200μm, C-E = 50 μm).

DESCRIPTION OF Botryohypoxylon amazonense AND Iledon versicolor

Botryohypoxylon Samuels & J.D. Rogers gen. nov.

Ascomata nigra, conferta, superficialia, sessilia vel stipitata, stromatica. Stroma erumpens, Botryosphaeria dothidea similis. Canalis apicalis periphysibus instructis. Asci bitunicati, clavati. Ascosporae unicellulares, brunneae; situs germinationis scissurae similis. Paraphyses filiformes, ramosae, basim et apicem affixae.

Ascomata clustered on a common, erumpent stroma, black, leathery. Asci bitunicate. Ascospores dark brown, unicellular, with an inconspicuous slit-like germination site. Pseudoparaphyses branched and anastomosed.

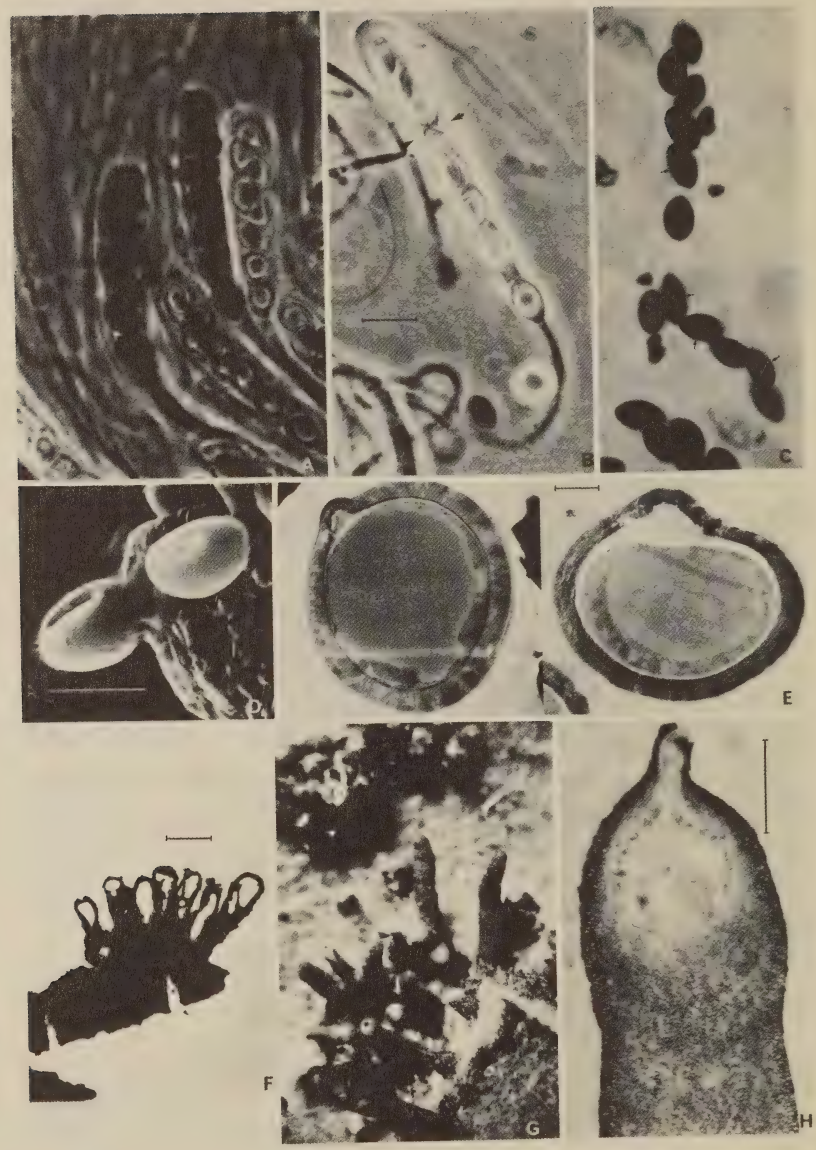

Fig. 2 Botryohypoxylon amazonense A: Asci with branching pseudoparaphyses. B: Dehisced bitunicate ascus, arrow indicates the point of dehiscence. C: Ascospores, arrows indicate spores that have visible germination sites. D: Two ascospores showing slit-like

Etymology of the generic epithet: refers to the botryose ascomata and the somewhat Hypoxylon-like ascospores.

Type species: B. amazonense Samuels & J.D. Rogers

Botryohypoxylon amazonense Samuels & J.D. Rogers, sp. nov. Figs. 1, 2 A-E, 3 A-C.

Characteribus generibus. Ascomata pyriformia, stipitata. Asci (40-)45-50(-55) x 7-9(-11) µm. Ascosporae (7-)8-9(-10) x 4-5 µm, leves.

Status anamorphosus Iledon versicolor Samuels & Rogers

Etymology of the specific epithet: refers to the amazonian region of Venezuela where the type specimen was found.

Iledon Samuels & Rogers, gen. nov.

Stroma erumpens. Pycnidia nigra, conferta, superficialia vel stipitata, unilocularia, eustromatica, pyriformia; poris apicalibus instructa. Cellulae conidiogenae phialides; a cellulis parietum pycnidiorum exorientes. Macroconidia et microconidia producta. Macroconidia septata, brunnea vel ad extremitates hyalinia. Microconidia oblongi, hyalinia.

Pycnidia eustromatic clustered on a common stroma, black, opening by a preformed pore, unilocular. Conidiogenous cells phialides, arising directly from the pycnidial wall. Macroconidia ellipsoidal, septate, intercalary cells transparent brown, terminal cells colorless. Microconidia bacillar, unicellular.

Etymology of the generic epithet: Ile (Greek): "clustered," refers to the clustered, botryose, nature of the pycnidia.

Iledon versicolor Samuels & J.D. Rogers sp. nov. Figs. 2 F-H, 3 D,E.

Characteribus generibus. Pycnidia pyriformia, sessilia vel stipitata. Phialides cylindricae, 10-12 x 1-2 µm. Macroconidia 9-11 x 4-5 µm, ellipsoideae, (0-)2-septata; cellula mediana brunnea, cellulae terminales hyalines. Microconidia ca. 4 x 1 µm, oblong, hyalinia.

Holotypus: ex cultura Samuels 1710 (GJS 84-532: Botryohypoxylon amazonense; VEN, NY).

Status teleomorphosus: Botryohypoxylon amazonense.

Etymology of the specific epithet: refers to the macroconidia that have a dark central cell and colorless terminal cells.

germination sites. E: Transverse sections through two ascospores showing a protruding germination site. F: Longitudinal section through several overmature pycnidia formed in nature. G: Columnar pycnidia formed in agar culture. H: Median longitudinal section through a pycnidium formed in culture. (Lines: A-C: 10 µm; D: 5 µm; E: 1 µm; F,G: 1 mm; H: 250 µm).

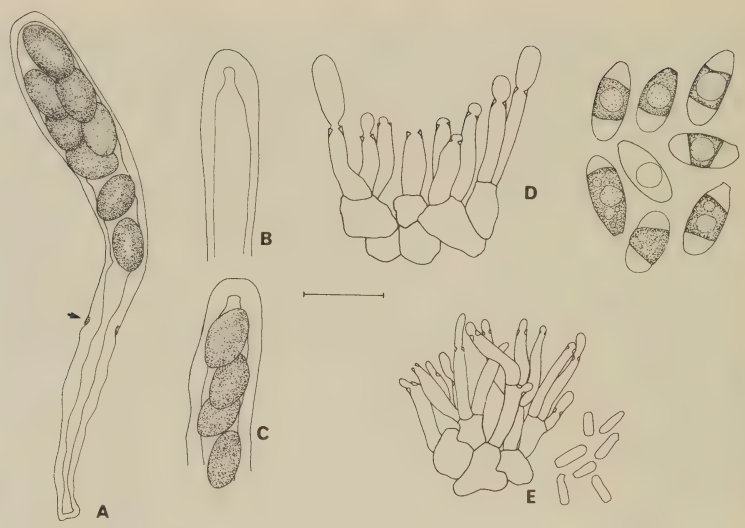

Fig. 3 Botryohypoxylon amazonense A: Dehisced ascus, arrow indicates the point of dehiscence. B: Immature ascus (Congo red). C: Mature, indehisced ascus (Congo red). D: Phialides and macroconidia. E: Phialides and microconidia. (Line = 10 µm).

Stromata subcortical, forming a distinct, thin, black, pseudoparenchymatous layer between cortex and wood with hyphae growing into the wood at scattered points; stromata breaking through the cortex at points and there up to 1 mm thick and composed of angular to circular, 10-30 x 10-15 µm cells with walls unevenly 1.5-4 µm thick, heavily pigmented; cells with long axes oriented perpendicular to the surface of the host. Pycnidia and ascomata arising from the surface of the stroma. Pycnidia with bases remaining immersed in the stroma or seated on a short pedestal, ca. 500 µm wide with locule oblong, 350-400 µm long x ca. 400 µm wide. Individual pycnidia compressed by mutual pressure, opening by a minute apical pore with wall 20-30 µm wide, consisting of angular cells and intertwined hyphae; cells short, ca. 10 x 6 µm. Pycnidia not collapsing when dry. No conidia or conidiogenous cells remain in the two known collections of this species.

Ascomata rarely solitary, more often cespitose in groups of 2-20, individually 600-700 µm diam. with locule ca. 550 µm diam. Each ascoma borne on a cylindrical 1 mm long x 0.5 mm wide pedestal, globose with a minute, acute papilla, only slightly wider than the pedestal, smooth, not collapsing when dry. Ascomatal wall ca. 120 µm thick, with three ± distinct regions. Outer region 25-30 µm wide, composed of cells textura angularis, with long axes perpendicular to the surface of the ascomatal wall, individual cells 5-10 µm in greatest dimension with pigmented walls 1-2 µm thick. Middle region 30-40 µm wide, cells ± textura epidermoidea, walls ca. 3 µm thick,

adjacent cells joined by ca. 0.5 µm wide pores. Inner region 10-20 um wide, the cells ± fusoid, 10-20 µm long x ≤ 0.5 µm thick, non-pigmented. Ascomatal apex composed of intertwined hyphae with lumens 1-2 µm wide and ca. 3 µm thick and pigmented, with cells at the surface ± textura angularis and continuous with cells of the surface of the wall below; within giving rise to finger-like periphyses, 10-15 x 5 µm, that line the ca. 150 µm long ostiolar canal. Asci (40-)45-50(-55) x 7-9(-11) µm, clavate, ascal cytoplasm abruptly narrowed below the ascospores at the point of dehiscence; bitunicate with thin ectoascus and endoascus rather thick throughout the entire length of the ascus; ascospores biseriate. Asci dehiscing at the midpoint, not bluing in Melzer's reagent and with no ring evident when stained in Congo Red but with conspicuous 'nasse apicale.' Asci forming a hymenium over the entire interior of the ascomatal wall. Ascospores (7-)8-9(-10) x 4-5 µm, unicellular, dark brown, nearly opaque, ellipsoidal, with what is possibly an inconspicuous germination site running the entire length of the spore and parallel to the long axis of the spore. Pseudoparaphyses ca. 2 um wide, forming a network between the asci, copious, branching, often from nodose regions, and anastomosing; free ends not seen.

CHARACTERISTICS IN CULTURE. Colonies grown one month at 20° C in diffuse daylight, on cornmeal dextrose agar (CMD), potato dextrose agar (PDA, Difco) and oatmeal agar (OA, Difco) 1-3 cm diam., faster on PDA than CMD or OA, colonies flat, surface of colony black, with or without scant, cinereous cottony aerial mycelium. Pycnidia forming sporadically on CMD and PDA, arising from a pseudoparenchymatous base, partially immersed and resembling naturally formed pycnidia or individually situated at the tip of a 4 mm long pedestal and then resembling ascomata. Pycnidial wall anatomically similar to naturally formed ascomatal wall, with entire wall of locule lined with conidiogenous cells. Ostiolar opening formed by disarticulation of small, 3-5 µm diam., thin-walled, colorless cells; conidiogenous cells not seen in the ostiolar canal. Macroconidia and microconidia forming within the same locule, the conidiogenous cells nearly identical but with macroconidial cells somewhat broader than microconidial cells. Conidiogenous cells cylindrical, 10-12 x 2-3 µm, tip with obvious periclinal thickening, not flared; arising directly from internal, non-pigmented cells of the pycnidial wall. Macroconidia 9-11 x 4-5µm, (0-)2 septate, ellipsoidal, lacking an obvious basal abscission scar, the central cell olivaceous and the end cells colorless or entire conidium colorless when unicellular. Microconidia ca. 4 x 1µm, oblong to ellipsoidal, unicellular, colorless.

HABITAT. On trunks of young, recently dead trees (? Leguminosae). Known only from type locality.

HOLOTYPE. VENEZUELA: T.F. Amazonas, Cerro de la Neblina, vic. Base Camp, on Rio Mawarinuma, ca. 140 m, 00° 50' N, 66° 10' W, on recently dead tree, Samuels (1703) & Thomas, 30 Apr 1984 (VEN. Isotype: NY).

ADDITIONAL SPECIMEN EXAMINED. Data as holotype, Samuels 1710 (VEN, NY; the dry culture from this specimen is the holotype of Iledon versicolor); second collection, same data, GJS 1669 (VEN, NY).

NOTE. Sessile pycnidia formed in culture were morphologically

identical to those found in nature; we did not see stalked pycnidia in nature although they were a conspicuous feature of cultures. The type specimen of Iledon versicolor is a dried agar culture.

The forest in the area where the three cited collections of B. amazonense were made comprised approximately 60 % leguminaceous trees (A.L. Gentry, pers. comm.) and it is on this basis that we suspect the host of the species to be leguminaceous. Stromata were erumpent through the bark over long distances of the trunks of recently fallen, young trees. For this reason we suspect that B. amazonense either contributed to the death of the trees or was at least an early secondary invader.

ACKNOWLEDGMENTS

The research was supported in part by grant 2736-83 from the National Geographic Society to the senior author and by National Science Foundation grant BSR-8407359 to the junior author.

The authors appreciate the comments of Dr Margaret Barr and Prof. Emil Müller. Michael J. Adams, Washington State University, performed the electron microscopy. The Latin diagnoses were corrected by Dr G. Kuschel, Entomology Division, DSIR.

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MYCOTAXON

Vol. XXV, No. 2, pp. 639-644 April-June 1986

NOTES ON HYGROPHORACEAE IX

CAMAROPHYLLOPSIS HERINK, AN OLDER NAME FOR HYGROTRAMA SING.

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SUMMARY

The generic name Camarophyllopsis Herink, typified by C. schulzeri (Bres.) Herink, has priority over Hygrotrama Sing., typified by H. dennisianum Sing. Some remarks are made on the delimitation, nomenclature and infrageneric classification of the genus. New combinations are proposed for one subgenus, two sections and nine species.

1. DELIMITATION OF THE GENUS CAMAROPHYLLOPSIS.

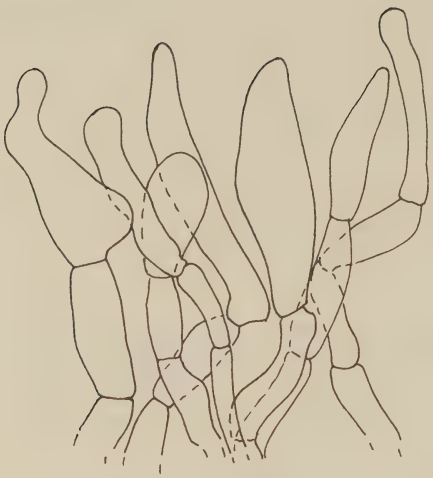
Camarophyllopsis Herink, at present better known as Hygrotrama Sing., is generally assigned to the Hygrophoraceae Lotsy. Until c. 1920 the species belonging there were usually placed in Hygrophorus sensu lato. Since ± 1920 an increasing number of authors preferred to split Hygrophorus Fr. into 3 genera: Hygrophorus Fr. sensu stricto (=Limacium Kummer), Hygrocybe (Fr.) Kummer and Cuphophyllus (Donk) M. Bon (= Camarophyllus sensu auct. non Fr., see note 1). The species of Camaro-

1) As Donk (1949, 1962) has pointed out, the name Camarophyllus must be based on Agaricus camarophyllus Fr. (1821) as the type. I agree with his statement that Fries (l.c.) apparently regarded that species as the most representative one of his subtribus Camarophylli. Since it was found later that Agaricus camarophyllus actually belongs to Hygrophorus sensu stricto in view of its bilateral hymenophoral trama, Camarophyllus has become a synonym of Hygrophorus. Many authors do not accept the view of Donk and wish to maintain Camarophyllus for a genus or subgenus for species with irregular hymenophoral trama, typified by Agaricus pratensis Pers.: Fr., e.g. Singer (1975).

Donk (1962) introduced the name Cuphophyllus in the rank of subgenus of Hygrocybe. In my opinion this is still the best taxonomic position (see Arnolds, 1986a). Bon (1984) raised this taxon without any new argument to the rank of genus and proposed 30 new combinations in Cuphophyllus. It should be stressed here that all these names are superfluous (but not illegitimate, ICBN art. 63.3) since Bon (l.c.) incorporated the older genus Aeruginospora Hoehn. (1908) (by Bon erroneously spelled "Aeruginosa") as a subgenus of Cuphophyllus. If Aeruginospora is a synonym of Cuphophyllus, as also suggested by Singer (1975), who made it a section of Camarophyllus, this is the correct name in the rank of genus. For name-hunters a lot of new combinations are to be made!

For this moment I cannot judge whether Aeruginospora and Cuphophyllus

*) Communication No. 295 of the Biological Station Wijster. Communication No.100 of the Department of Plant Ecology of the Agricultural University, Wageningen.



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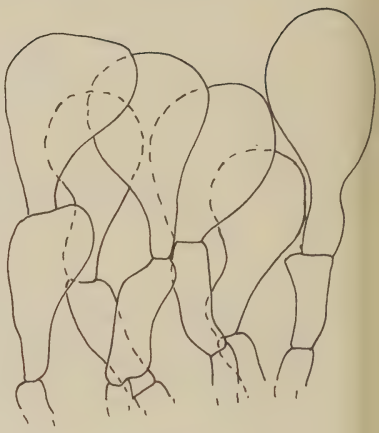

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Fig. 1. Camarophyllopsis schulzeri, radial section of pileipellis, x 850 (from H. Huyzer, 24 Oct. 1980, Herb. Biol. Station Wijster = WBS). - Fig. 2. Camarophyllopsis phaeophylla, radial section of pileipellis, x 850 (from Arnolds 4469, WBS).

phyllopsis were placed then in either Cuphophyllus or Hygrocybe. The group is characterized in macroscopic respect by small basidiocarps with broadly adnate to decurrent lamellae and dull (brown, grey, ochre) colours. The hymenophoral trama is subregular to rather irregular, often intermediate between typical Hygrocybe and Cuphophyllus. The spores are always relatively small, 3-7x2.5-5 µm. Clamps are absent in most species. The pileipellis is, at least in places, either a trichodermium made up of erect hyphae with inflated cells and often cystidiform terminal cells (Fig.1), or a hymeniderm (Fig.2), made up of several layers of strongly inflated, pyriform to globose cells (cf. Singer, 1975: 202; Arnolds, 1986b). These types of pileipellis are not sharply separated. For instance, most authors described the pileipellis of the type species C. schulzeri (Bres.) Herink as a trichodermium with clavate terminal cells (e.g. Herink, 1958: 63; Horak, 1968: 140). However, Moser (1978b: 7, Fig.3) reported that in young basidiocarps the terminal cells are subglobose, (15-25x15-20µm), but not closely packed as in a true hymeniderm.

The structure of the pileipellis is the most important diagnostic character to distinguish Camarophyllopsis from Hygrocybe and Cuphophyllus. Some dull-coloured species in Hygrocybe may have trichodermial tufts near the centre of the

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are really synonyms. Therefore I will use here the name Cuphophyllus only provisionally to indicate the group of species and without recognition as a genus in its own right.

pileus (e.g. H. nitrata (Pers.: Fr.) Wünsche), but they always lack subglobose cells in the pileipellis and have another habit: medium-sized to large basidiocarps with non-decurrent lamellae.

Related taxa with small, dull-coloured basidiocarps and small spores were described by Hesler & Smith (1963) in the subsection Microspori (A.H. Smith & Hesl.) of Hygrophorus sect. Camarophyllopsis Hesl. & A.H. Smith (non Camarophyllopsis Herink!) = Cuphophyllus (Fr.) M. Bon. In most of these species the pileipellis is a cutis of repent hyphae. Some species with a trichodermal pileipellis, such as Hygrophorus microsporus A.H. Smith & Hesl., H. peckianus Howe and H. paupertinus A.H. Smith & Hesl. have been transfered to Hygrotrama by Singer (1973). I did not study these species myself, but this solution seems to be correct.

Some modern authors treat Hygrotrama (= Camarophyllopsis) only on infrageneric level: Hesler & Smith (l.c: 96) regard it as a section of Hygrophorus and Orton & Watling (1969: 137) as a section of Hygrocybe. I agree with Singer (1975) and Kühner (1980), who argue that this group of fungi has a combination of characters sufficient to distinguish it in the rank of genus. This view is shared by e.g. Moser (1978a) and Gulden & Weholt (1984).

2. NOMENCLATURAL CONSIDERATIONS.

Heim (1957: 196) was the first author to distinguish this taxonomic group in the rank of genus. He introduced the name Hodophilus, but this name was invalidly published because no latin diagnosis was provided. Hodophilus was not validated until Heim published a latin diagnosis in 1966 (:231). Bon (1977:44) claims that Hodophilus was validated earlier by Herink in 1958 (: 61). Although Herink mentioned some characters of Hodophilus in latin (his complete publication was written in latin) I regard this name only as incidentally mentioned (ICBN art. 34). Moreover Herink (l.c) did not indicate a type species and he enumerated three species, so that his name is definitely invalid (art. 37). Since H. foetens was the only species listed in the validating paper by Heim (1966) it is automatically the type of Hodophilus.

In 1958 Herink published in a rather obscure journal, officially entitled Sborník Severočeského Muzea (or in latin Acta Musei et Horti bot. Bohemiae borealis), the valid genus name Camarophyllopsis, typified by Hygrophorus schulzeri Bres.(also only species mentioned). According to Singer (1975: 202) Herink's publication was not published in 1958 - as indicated on the journal but in July 1959. This is probably based on the date of distribution of reprints by Herink. At my request Dr. J. Klán (Prague) checked the date of publication and wrote me that the indicated issue of this journal was officially registered in the State library of Czechoslovakia on October 28, 1958 (nr. 54674734).

The exact date of publication is important since Singer published the name Hygrotrama only a few months later; according to his own work the month of effective publication was March 1959. The holotype of Hygrotrama is H. dennisianum Sing.

A few years later Singer (1962: 189) regarded Aeruginospora Hoehn. (1908) as the correct name of this genus. This idea was accepted for example by Moser (1967: 69). Horak (1968: 65) published a detailed analysis of the holotype of the type species,

Aeruginospora singularis Hoehn. It appears that the pileipellis is made up of erect, but very slender hyphae, without diferentiated terminal cells, only 2-3.5 µm wide, so quite different from the species in Camarophyllopsis. Besides the spores posess a characteristic refractive pigment, according to von Höhnel blue under the microscope. On the basis of the structure of the pileipellis Aeruginospora was reduced by Singer (1975) to a section of the genus Camarophyllus Kummer (= Cuphophyllus (Donk) M. Bon).

The conclusion is that three validly published genus names are available, all typified by different species. If these species are considered to belong to one genus (see 3) the name Camarophyllopsis has priority.

3. INFRAGENERIC CLASSIFICATION.

The genus can be divided into two groups on the basis of the structure of the pileipellis: one with a trichodermium, the other with a hymeniderm. In the latter group a division can be made into species with and without clamp connections. This classification agrees with the classification proposed by Singer (1975) for Hygrotrama. It is remarkable that the type species of each of the genera mentioned before belong to a different section. I propose the following subdivision:

Camarophyllopsis subg. Camarophyllopsis
Holotype: C. schulzeri (Bres.) Herink

Camarophyllopsis subg. Hygrotrama (Sing.) Arnolds
nov. comb.
Basionym: Hygrotrama Sing. in Sydowia 12:221.1959
Holotype: C. dennisiana (Sing.) Arnolds

Camarophyllopsis sect. Hygrotrama (Sing.) Arnolds
nov. comb.
Basionym: as above
Holotype: as above

Camarophyllopsis sect. Hodophilus (R. Heim ex R. Heim) Arnolds
nov. comb.
Basionym: Hodophilus R.Heim ex.R. Heim in Revue Mycologie 30:231.1965.
Holotype: C. foetens (Phill. in B. & Br.) Arnolds

4. NEW COMBINATIONS FOR SOME SPECIES OF CAMAROPHYLLOPSIS.

New combinations are proposed for species studied by the author himself (marked with *, full descriptions to be published in Arnolds, 1986) and for species undoubtedly belonging here and, judging from their descriptions, deserving the rank of species.

*Camarophyllopsis atropuncta (Pers.) Arnolds.
nov. comb.
Basionym: Agaricus atropunctus Pers.:Syn. Fung.: 353.1801.

Camarophyllopsis dennisiana (Sing.) Arnolds
nov. comb.
Basionym: Hygrotrama dennisianum Sing. in Sydowia 12: 221 1959 ("1958").

Camarophyllopsis hiemalis (Sing. & Clemençon) Arnolds *nov. comb.*
Basionym: Aeruginospora hiemalis Sing. & Clemençon in Schweiz. Z. Pilzk. 49: 118. 1971.

*Camarophyllopsis foetens (Phill. in B. & Br.) Arnolds *nov. comb.*
Basionym: Hygrophorus foetens Phill. in B. & Br. in Ann. Mag. nat. Hist., Ser. V (3): 207. 1879.

Camarophyllopsis hymenocephala (A.H. Smith & Hesl.) Arnolds *nov. comb.*
Basionym: Hygrophorus hymenocephalus A.H. Smith & Hesl. in Elisha Mitchell Sci. Soc. Jour. 56: 31. 1940.

*Camarophyllopsis phaeophylla (Romagn.) Arnolds *nov. comb.*
Basionym: Hygrophorus rugulosus var. phaeophyllus Romagn. in Bull. trimest. Soc. mycol. Fr. 86: 874. 1971 ("1970").

*Camarophyllopsis phaeoxantha (Romagn.) Arnolds *nov. comb.*
Basionym: Hygrophorus phaeoxanthus Romagn in Bull. trimest. Soc. mycol. Fr. 86: 873. 1971("1970").

Camarophyllopsis rugulosa (A.H. Smith & Hesl.) Arnolds *nov. comb.*
Basionym: Hygrophorus rugulosus in Sydowia 8: 330. 1954.

Camarophyllopsis subfuscescens (A.H. Smith & Hesl.) Arnolds *nov. comb.*
Basionym: Hygrophorus subfuscescens A.H. Smith & Hesl. in Sydowia 8: 317. 1954.

4. ACKNOWLEDGEMENTS.

Thanks are due to Dr. J. Klan and Dr. Z. Pouzar (Praha) for their help in tracing the day of publication of Herink's paper. I am indebted to Drs. Th. Kuyper (Wijster) for critical reading of the manuscript and for checking of the nomenclature.

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MYCOTAXON

Vol. XXV, No. 2, pp. 645-655 April-June 1986

OPHIOVALSA IN THE PACIFIC NORTHWEST

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Recently we identified four species of the genus **Ophiovalsa** Petrak (≡ **Cryptospora** Tul. **fide** Petrak, 1965) from the Pacific Northwest for the first time. This paper includes descriptions, illustrations, and a key for **O. betulae, O. femoralis, O. suffusa,** and **O. valsoides** (a new combination), the species presently known to occur there. Further collecting in this region seems likely to uncover additional species.

KEY TO SPECIES OF **OPHIOVALSA** IN THE PACIFIC NORTHWEST

1a. Four spores per ascus; ascospores with minute, hyaline appendages; asci usually indehiscent . . . . . **Ophiovalsa valsoides.**

1b. Eight spores per ascus; ascospores lacking appendages; asci dehiscent . . . . . 2a.

2a. Stromata with well-developed dark, pseudoparenchymatous region in center; ascospores usually 4-6 µm wide; on **Betula** . . . . . **Ophiovalsa betulae.**

2b. Stromata lacking well-developed central pseudoparenchymatous zone; ascospores usually narrower; on **Alnus** . . . . . 3a.

3a. Asci usually shorter than 80 µm; asci lacking refractive apical ring; ascospores usually nearly straight,

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femur-shaped . . . . . **Ophiovalsa femoralis.**

3b. Asci usually longer than 80 µm; asci with refractive apical ring; ascospores usually curved, cylindrical to filiform, not femur-shaped . . . . **Ophiovalsa suffusa.**

Ophiovalsa betulae (Tul.) Petrak, Figs. 1, 5, 6, 12-18.

Stromata immersed in bark; **ca.** 1.6-2.4 mm diam.; circular to elliptical (Fig. 6); convex to subconic; exterior dark brown to black; ostioles black, circular; with brown region of pseudoparenchyma between perithecial necks (Fig. 5). Perithecia with long, convergent necks; centrum at maturity filled with paraphyses and dehisced asci (Fig. 14); peridia **textura angularis** (Fig. 1); **ca.** 0.5 mm diam. **Asci** clavate (Fig. 12), containing eight spores; dehiscent, with refractive apical rings (Fig. 13), (70-)90-108(-112) X 12-16 µm. **Ascospores** allantoid to long-cylindrical or filiform, usually curved or bent (Figs. 15-18), single-celled, multiguttulate, pale yellow, (12-)24-54(-62) X 4-6 µm.

On branches of **Betula papyrifera.**

This species differs from others in this region in the wider ascospores, and in the well-developed, central pseudoparenchymatous zone in the stroma. Ascospores in this species tend to be quite variable in size.

Specimens examined: IDAHO: D. A. Glawe No. 79-333, 13.X.1979, 2.1 km up Smith Lake Road from Highway 95, 8.1 km N Bonners Ferry, Boundary Co., on **Betula papyrifera** Marsh. D. A. Glawe No. 79-371, 14.X.1979, and D. A. Glawe No. 79-372, 14.X.1979, 3.2 km up Benton Creek Road, Priest River Experimental Forest, Bonner Co., on **Betula papyrifera** Marsh.

Ophiovalsa femoralis (Peck) Petrak, Figs. 2, 7, 8, 19-22.

Stromata immersed in bark; 0.5-1.5 mm diam.; circular to elliptical (Fig. 8); convex to subconic (Fig. 7); ostioles black, circular. Perithecia with long, convergent necks; centrum at maturity filled with dehiscent asci and deliquescent paraphyses; peridia **textura angularis** (Fig. 2); 0.3-0.6 mm diam. **Asci** fusoid to clavate (Fig. 22), containing eight spores, dehiscent, lacking identifiable apical rings (Fig. 19), 60-80(-84) X (11-)12-18 µm. **Ascospores** nearly straight, single-celled, typically femur-shaped but sometimes lacking widened ends (Figs. 20,

21), multiguttulate, pale yellow, (28-)32-48(-52) X (2-)3-4 µm, (3-)4-6 µm wide at ends.

On **Alnus rubra.**

Major distinguishing features of this species are the femur-shaped ascospores, and the asci which lack apical rings. According to Kobayashi (1970) and Barr (1978), ascospores in collections from other regions often are one-septate, but those examined in the present study were aseptate. As Kobayashi (1970) noted, ascospore septation seems to be a variable characteristic in this species.

Specimens examined: OREGON: D. A. Glawe No. 80-225, 8.V.1980, and D. A. Glawe No. 80-233, 8.V.1980, and D. A. Glawe No. 80-245, 8.V.1980, Wildwood Recreational Area, near Sandy, Clackamas Co., on **Alnus rubra** Bong. WASHINGTON: D. A. Glawe No. 79-228, 14.IX.1979, Beacon Rock State Park, Skamania Co., on **Alnus rubra** Bong. J. D. Jensen No. 4/3/82/1, 3.IV.1982, Granite Falls, near Snohomish, Snohomish Co., on dead hardwood.

Ophiovalsa valsoides (Rehm) D. A. Glawe & J. D. Jensen, **comb. nov.**, Figs. 3, 10, 11, 23-27.

≡**Cryptospora suffusa** var. **valsoides** Rehm, **Ann. Mycol.** 4: 76. 1906.

Stromata immersed in bark; 0.8-1.4 mm diam.; circular to elliptical (Fig. 10); convex to subconic (Fig. 11); ostioles black, circular; often with blackened zone beneath perithecia. Perithecia with long convergent necks, the centrum at maturity containing asci intermingled with paraphyses (Fig. 24), peridia **textura epidermoidea** to **textura angularis** (Fig. 3), 0.3-0.45 mm diam. **Asci** cylindrical to clavate (Fig. 23), containing four spores, indehiscent, with refractive apical rings (Fig. 25), (79-)88-112(-115) µm. **Ascospores** variously curved (Fig. 27); (1-)2-4 or more septate; filiform; with **ca.** 1 µm long, hyaline appendage at each end (Fig. 26); multiguttulate; pale yellow; (46-)56-85(-92) X (2-)3-4(-5) µm.

On **Alnus tenuifolia.**

Ascospore appendages are nearly impossible to see with bright-field microscopy, and are best viewed with interference contrast microscopy. Ascospore septa are difficult to see in unstained material, but are easily seen in material mounted in Melzer's solution.

Although Rehm (1906) regarded this as a variety of **C. suffusa**, critical examination of material of both species, and cultural studies, do not support this view. The

following differences between the two species were found: **O. valsoides** ascospores are filiform, multiseptate, and have a minute, hyaline appendage at each end, while **O. suffusa** ascospores tend to be cylindrical, single-celled, and lack appendages; **O. valsoides** asci each contain four ascospores and remain attached to the hymenium, while **O. suffusa** asci contain eight ascospores and are dehiscent at maturity; in culture on potato dextrose agar under alternating light and darkness **O. valsoides** forms fertile perithecia while **O. suffusa** does not form the teleomorph. In our opinion these differences make it impossible to view these fungi as conspecific. In fact, one might argue, based on the ascospore appendages, centrum type (**i.e.**, indehiscent asci), and four-spored asci, that **O. valsoides** should be excluded from the genus **Ophiovalsa**, since these features differ from that genus as exemplified by the type, **O. suffusa.** However, because so little information about **Ophiovalsa** is available it seems preferable to retain this fungus in the genus until more conclusive evidence is available.

Specimens examined: AUSTRIA: HOLOTYPE (in S) F. von Hoehnel, (det. H. Rehm), 1902, Niederoesterreich: Wechsel, on **Alnus viridis**, (as **Cryptospora valsoides** Tul. var. **valsoides** Rehm). IDAHO: D. A. Glawe No. 81-16, and No. 85-209, (both coll. M. MacKenzie and D. A. Glawe), 17.X.1980, Dry Fork, Laird Park, Latah Co., on **Alnus tenuifolia** Nutt. J. D. Jensen (Glawe No. 85-214), 14.IX.1983, Laird Park, Latah Co., on **Alnus tenuifolia** Nutt.

Ophiovalsa suffusa (Fr.) Petrak, Figs. 4, 9, 28-32.

Stromata immersed in bark; 0.6-1.6 mm diam.; circular to elliptical (Fig. 9); subconic; ostioles black, circular. Perithecia with long convergent necks; centrum at maturity filled with dehiscent asci; peridia **textura angularis** to **textura epidermoidea** (Fig. 4); 0.3-0.6 mm diam. **Asci** clavate to fusiform (Fig. 28), containing eight spores, dehiscent, with refractive apical rings (Fig. 29), (40-)50-100(-128) X (12-)14-20(-24) µm. **Ascospores** nearly straight to curved (Figs. 30-32), single-celled, cylindrical to filiform, multiguttulate, pale yellow, 34-90(-96) X 3-6 µm.

On **Alnus** species.

See discussion of **O. valsoides** for further comments.

Specimens examined: IDAHO: J. D. Jensen No. 9/10/80/10X (coll. J. D. Jensen, J. D. Rogers, and D. A.

Glawe), 10.IX.1980, near Deception Creek, Kootenai Co., on **Alnus sinuata**? (Regel) Rydb. D. A. Glawe No. 85-213 (coll. J. D. Jensen), 2.IV.1980, Laird Park, Latah Co., on **Alnus tenuifolia** Nutt. J. D. Jensen No. 7/1/80, 1.VII.1980, Alder Meadow, Laird Park, Latah Co., on **Alnus** sp. J. D. Jensen No. 7/2/80/X, 2.VII.1980, Alder bottom, Laird Park, Latah Co., on **Alnus** sp.

Illinois Agricultural Experiment Station Project 68-0331. We thank Professor J. D. Rogers, Washington State University, for supplying facilities and support for a portion of this research, Professors J. Reid, University of Manitoba, and M. E. Barr, University of Massachusetts for helpful comments, and Professors Barr and Rogers for reviewing the manuscript. We thank the curators of the Naturhistoriska Riksmuseet, Stockholm for loaning the type of **Ophiovalsa valsoides**.

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Rehm, H. 1906. Zum Studium der Pyrenomyceten Deutschlands, Deutsch-Oesterreichs und der Schweiz. **Ann. Mycol.** 4: 471-482.

Figure Legends

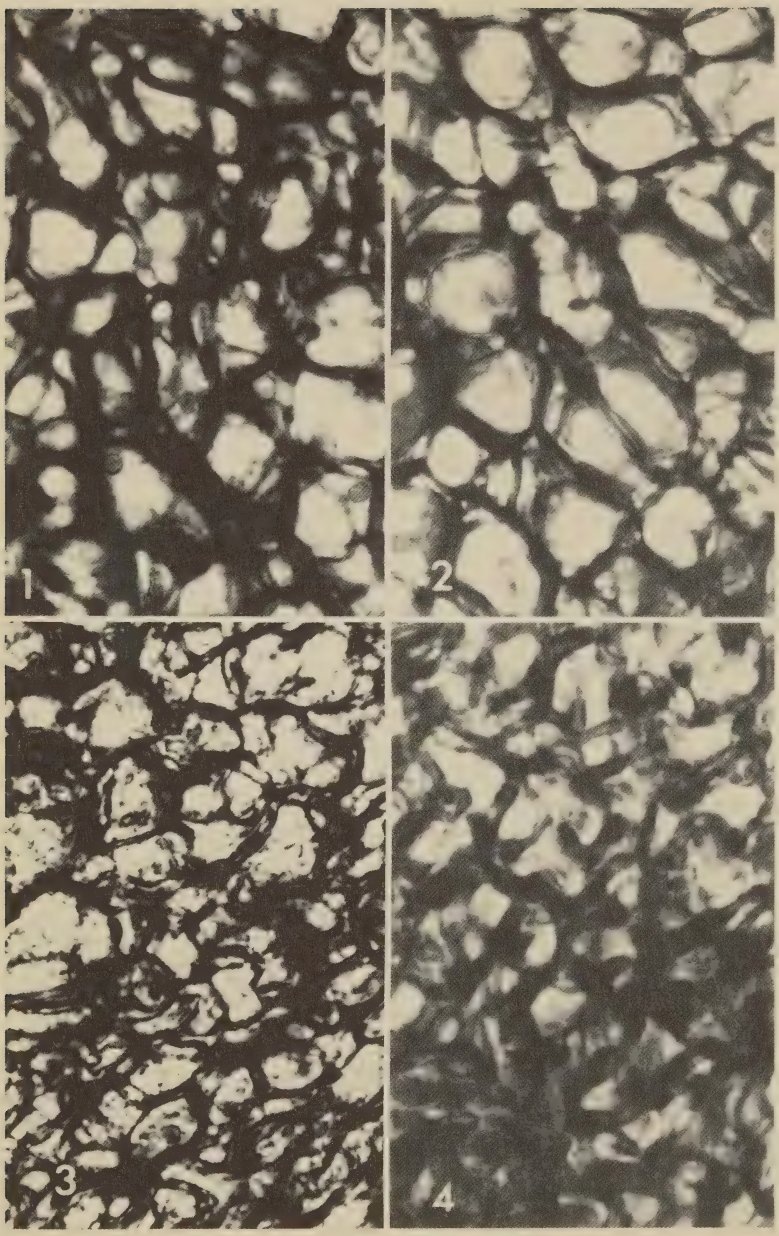
Figs. 1-4. Perithecial peridia of **Ophiovalsa** species. 1. **O. betulae.** 2. **O. femoralis.** 3. **O. valsoides.** 4. **O. suffusa.** All X1000.

Figs. 5-11. Perithecial stromata of **Ophiovalsa** species. 5, 6. **O. betulae.** 5. Longitudinal section showing perithecium (arrow) and central pseudoparenchyma (P). 6. Surface. 7, 8. **O. femoralis.** 7. Longitudinal section. 8. Cross section. 9. **O. suffusa,** cross section, arrow designates ostiolar disc of adjacent stroma. 10, 11. **O. valsoides.** 10. Cross section, surface view of adjacent stroma. 11. Longitudinal sections of stromata. Figs. 6, 8-10 X10. Fig. 5 X30. Fig. 7 X20. Fig. 11 X8.

Figs. 12-21. **Ophiovalsa betulae** and **O. femoralis.** 12-18. **O. betulae.** 12. Ascus. 13. Apical region of ascus, with refractive ring (arrow). 14. Centrum material, including paraphyses (arrow). 15-18. Ascospores. 19-21. **O. femoralis.** 19. Apical region of ascus. Note absence of apical ring. 20, 21. Ascospores. Figs. 12, 15-18, 20, 21 X1000. Figs. 13, 19 X2500. Fig. 14 X250.

Figs. 22-27. **O. femoralis** and **O. valsoides.** 22. **O. femoralis.** Ascus. 23-27. **O. valsoides.** 23. Asci. 24. Centrum material including paraphyses (arrow) and asci. 25. Apical regions of asci, each with refractive ring (arrows). 26. End of ascospore with appendage (arrow). 27. Ascospore. Figs. 22, 23, 27 X1000. Figs. 25, 26 X2500. Fig. 24 X250.

Figs. 28-32. **Ophiovalsa suffusa.** 28. Ascus. 29. Apical region of ascus with refractive ring (arrow). 30. End of ascospore. Note lack of appendage. 31, 32. Ascospores. Figs. 28, 31, 32 X1000. Figs. 29, 30 X2500.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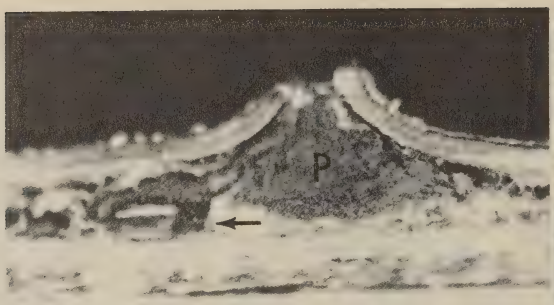

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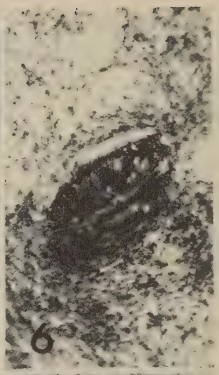

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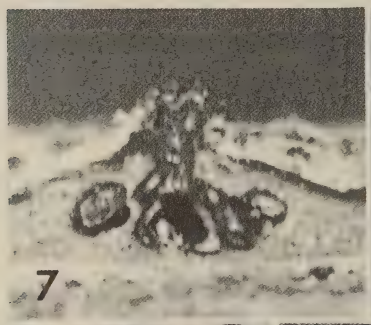

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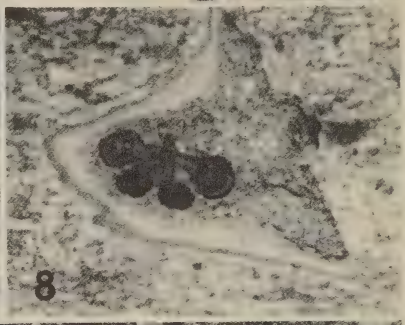

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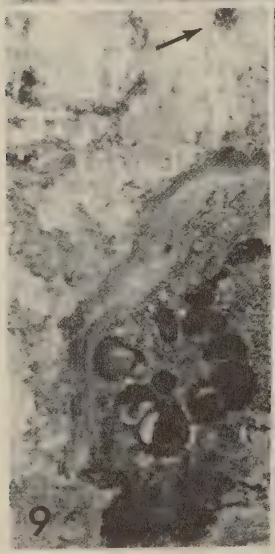

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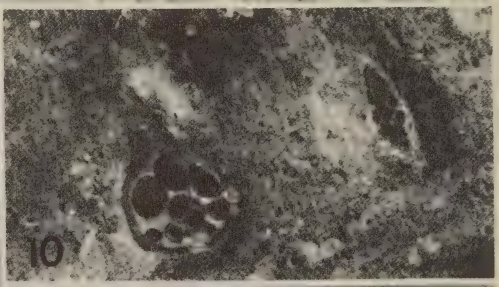

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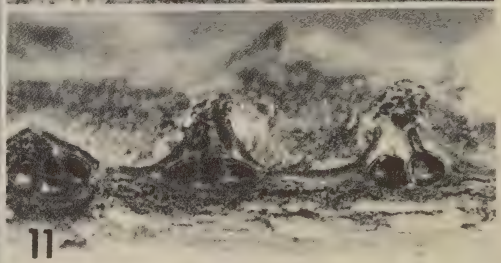

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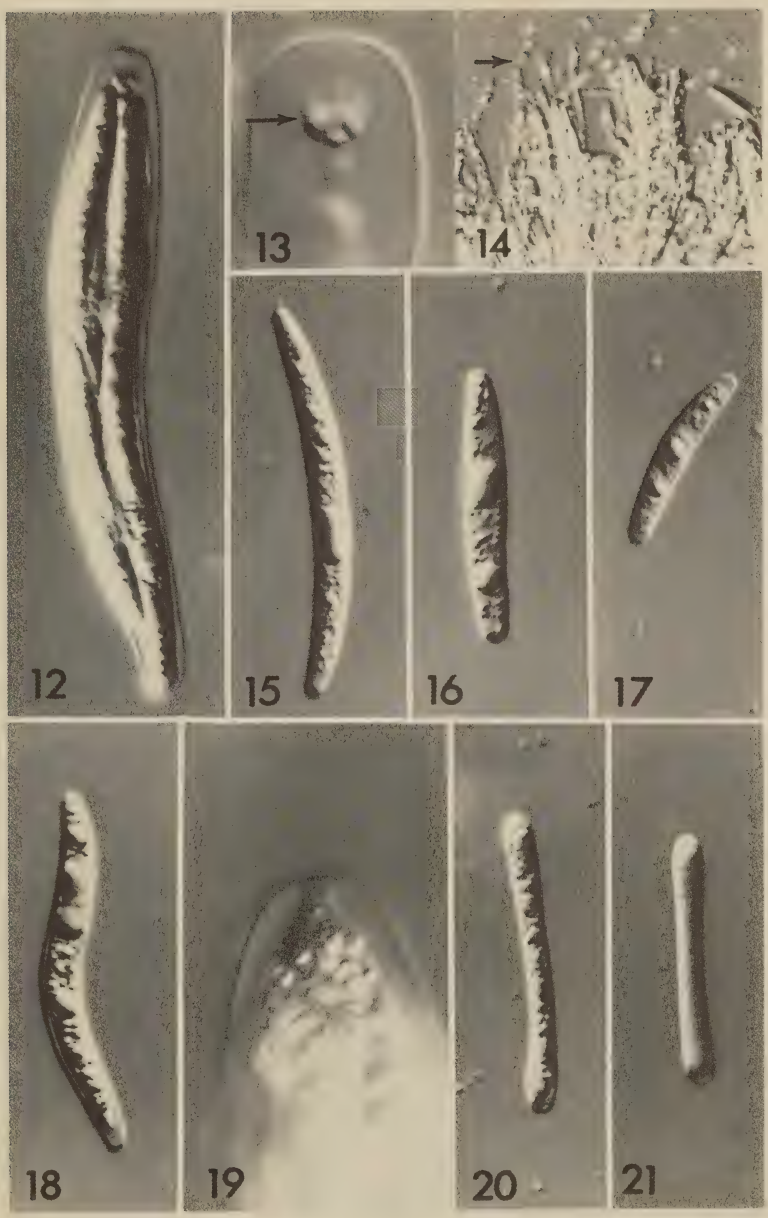
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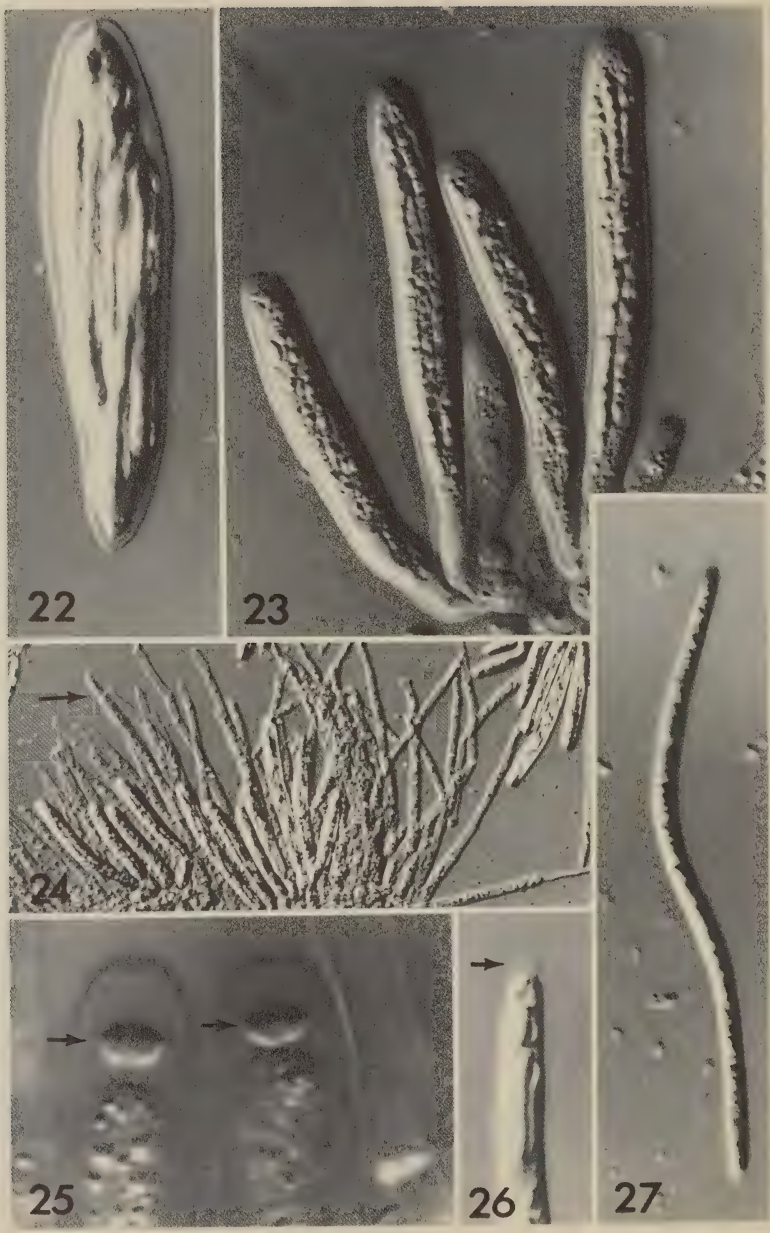
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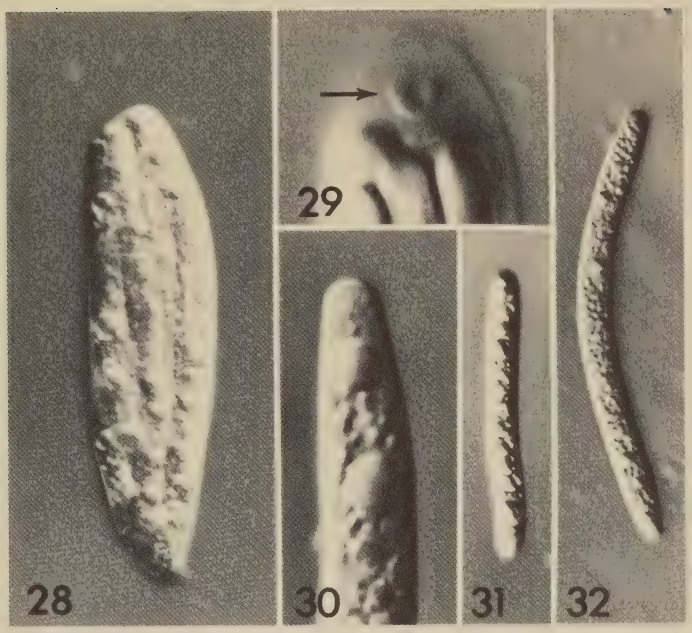
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31
32

MYCOTAXON

Vol. XXV, No. 2, p. 657 April-June 1986

NOTICE

A CHANGE IN EDITORIAL POLICY FOR LONG PAPERS

It is with some reluctance that we at MYCOTAXON institute, beginning with volume 26, a policy whereby full support of publication costs of longer papers shall no longer be carried by the subscription fees. Though we are still opposed to the philosophy of page charges, we have increasingly been asked to publish long, even book-length, articles.

In order to satisfy our subscribers, we must now charge partial costs for each page submitted over 64 pages for an article (or articles with the same author or the same senior author appearing in any one volume). Authers will be well advised to plan their long papers carefully - giving full thought to possible typeface reduction to achieve savings in number of pages. Advice on article preparation is always available from either of the Co-Editors.

This new policy will allow us in the future to increase the size of volumes that contain such long articles without any additional cost to subscribers.

We shall continue to offer authors the preparation cost of one free halftone for each 10 pages of the paper.

Charges for each excess halftone and for each page in excess of 64 pages are currently $15.00 (U.S.), but are subject to change as printing costs vary. These will be specified on the acceptance form sent authors, or may be ascertained beforehand by writing to the Managing Editor.

AUTHOR INDEX, VOLUME TWENTY-FIVE

AJELLO, L., see WEITZMAN & al.
ANON. NOTICE: Deadline for proposals to amend the Code of Botanical Nomenclature at the XIV International Botanical Congress 309
ANON. NOTICE: A change in editorial policy for long papers 657
ARENDHOLZ, WOLF-RUDIGER, see SHARMA & al.
ARNOLDS, EEF. Notes on Hypgrophoraceae IX: **Camarophyllopsis** Herink, an older name for **Hygrotrama** Sing. 639-644
ARX, J. A. VON. **Tolypocladium**, a synonym of **Beauveria** 153-158
BALAZY, STANISLAV & ANNA BUJAKIEWICZ. A new entomogenous species of **Cordyceps: Cordyceps ithacensis** sp. nov. 11-14
BARR, MARGARET E., see CHECA & al., see CORLETT & BARR
BARRON, G. L., see THORN & BARRON
BEN-ZE'EV, ISRAEL S. Notes on Entomophthorales (Zygomycotina) collected by T. Petch: **Erynia anglica** comb. nov. and **Erynia coleopterorum** 1-10
BILLS, GERALD F. **Russula vesicatoria** and **Russula angustispora** sp. nov., two confusing species of **Russula** subsection **Lactarioideae** 607-620
BISSETT, JOHN. A note on the typification of **Guignardia** 519-522
BLACKWELL, MEREDITH & WALTER ROSSI. Biogeography of fungal ectoparasites of termites 581-601
BLOSS, H. E., see WALKER & al.
BONONI, VERA LUCIA RAMOS, see HJORTSTAM & BONONI
BRAUN, UWE. Taxonomic notes on some powdery mildews of various genera 259-269
BRUSSE, FRANKLIN A. **Dermatiscum fallax** (Physciaceae), a new lichen from southern Africa 161-164
BUJAKIEWICZ, ANNA, see BALAZY & BUJAKIEWICZ
CANNON, PAUL F., see HORIE & al.
CARRANZA-MORSE, J. & R. L. GILBERTSON. Taxonomy of the **Fomitopsis rosea** complex (Aphyllophorales, Polyporaceae) 469-486
CHAMURIS, GEORGE P. Modification of Nobles' species code for identification of basidiomycete cultures 159-160
CHECA, J., G. MORENO & MARGARET E. BARR. **Valseutypella multicollis** sp. nov. 523-526
CORLETT, MICHAEL & MARGARET E. BARR. **Hormotheca** for species of **Coleroa** with hemispherical ascomata 255-257
CRANE, J. L., see SHEARER & CRANE
DE COCK, A. W. A. M. Marine Pythiaceae from decaying seaweeds in the Netherlands 101-110
ERIKSSON, O. & R. SANTESSON. **Lasiosphaeriopsis stereocaulicola** 569-580
FARR, DAVID F. Experiences in computerizing the National Fungus Collections' specimen label data 175-182
GILBERTSON, R. L., see CARRANZA-MORSE & GILBERTSON
GLAWE, DEAN A. Taxonomic notes on **Diatrypella discoides**, **Diatrypella decorata**, and **Diatrypella placenta** 19-25
GLAWE, DEAN A. & JON D. JENSEN. **Ophiovalsa** in the Pacific northwest 645-655
HALE, MASON E., Jr. **Arctoparmelia**, a new genus in the Parmeliaceae (Ascomycotina) 251-254
HALE, MASON E., Jr. **Flavoparmelia**, a new genus in the lichen family Parmeliaceae (Ascomycotina) 603-605
HALE, MASON E., Jr. New species in the lichen family Parmeliaceae (Ascomycotina) 85-93

HAMAOKA, TAKAFUMI, see UDAGAWA & al.
HENNEBERT, G. L. Revue des Livres 311-320
HENSSEN, AINO. **Thyrea polyglossa** and **Thyrea divergens** sp. nov. 493-503
HORIE, YOSHIKAZU, SHUN-ICHI UDAGAWA & PAUL F. CANNON. Four new Japanese species of the Ceratostomataceae (Ascomycetes) 229-245
HJORTSTAM, KURT. Notes on Corticiaceae (Basidiomycetes) XIV 273-277
HJORTSTAM, KURT & VERA LUCIA RAMOS BONONI. Studies in tropical Corticiaceae (Basidiomycetes) VI: A new species of **Steccherinum** from Brazil 467-468
HJORTSTAM, KURT & LEIF RYVARDEN. Some new and noteworthy fungi (Aphyllophorales, Basidiomycetes) from Iguazu, Argentina 539-567
JENSEN, JON D., see GLAWE & JENSEN
JONG, SHUNG-CHANG, see LEE & JONG
JONG, SHUG-CHANG & FWU-LING LEE. The new species **Dekkera naardenensis**, teleomorph of **Brettanomyces naardenensis** 147-152
KAMAL, R. V. VERMA & GARETH MORGAN-JONES. Notes on hyphomycetes. LI. **Kameshwaromyces**, a new foliicolous, sooty mold-like genus from Madhya Pradesh, India 247-250
KENDRICK, BRYCE, see NAG RAJ & KENDRICK
KIMBROUGH, JAMES W. Typification of **Dimeromyces isopterus** (Laboulbeniales) 271
LEE, FWU-LING, see JONG & LEE
LEE, FWU-LING & SHUNG-CHANG JONG. New species **Dekkera custersiana** and **D. lambica**, teleomorphs of **Brettanomyces** 455-460
LINDSEY, J. PAGE. Basidiomycetes that decay Gambel oak in southwestern Colorado: II 67-83
McGINNIS, M. R., see WEITZMAN & al.
MILLER, DIANE DOUD & CHRISTOPHER WALKER. **Glomus maculosum** sp. nov. (Endogonaceae): an endomycorrhizal fungus 217-227
MORENO, G., see CHECA & al.
MORGAN-JONES, GARETH, see KAMAL & al., see WHITE & MORGAN-JONES
NAG RAJ, T. R. & BRYCE KENDRICK. On **Dinemasporium adeanum** Petrak 15-18
PADEN, JOHN W. On the anamorph of **Phillipsia crispata** 165-171
PADHYE, A. A., see WEITZMAN & al.
PFEIFFER, C. M., see WALKER & al.
PFISTER, DONALD H. A corrected authors index for A Bibliographic Account of Exsiccatae Containing Fungi 141-145
ROGERS, JACK D., see SAMUELS & ROGERS
ROSSI, WALTER, see BLACKWELL & ROSSI
RYVARDEN, LEIF, see HJORTSTAM & RYVARDEN
SAMUELS, GARY J. & JACK D. ROGERS. **Botryohypoxylon** gen. nov. and its anamorph, **Iledon** gen. nov. 629-637
SANTESSON, R., see ERIKSSON & SANTESSON
SCHENCK, N. C., JOYCE L. SPAIN & EWALD SIEVERDING. A new sporocarpic species of **Acaulospora** (Endogonaceae) 111-117
SCHNEIDER, ALAIN. Observation d'un **Taphrina** parasite sur **Polystichum setiferum** (Forskall) Moore ex Woynar en France 487-491
SHARMA, RAGHUNANDAN, WOLF-RUDIGER ARENDHOLZ & K. S. THIND. Some more observations on eastern Himalayan Helotiales 119-140
SHEARER, C. A. & J. L. CRANE. Illinois fungi XII. Fungi and myxomycetes from wood and leaves submerged in southern Illinois swamps 527-538
SIEVERDING, EWALD, see SCHENCK & al.

SIMMONS, EMORY G. **Alternaria** themes and variations (14-16) 195-202
SIMMONS, EMORY G. **Alternaria** themes and variations (17-21) 203-216
SIMMONS, EMORY G. **Alternaria** themes and variations (22-26) 287-308
SPAIN, JOYCE L., see SCHENCK & al.
TAN, HUI-CI & REN-JIAN WU. The ecological and geographical distribution of 108 species of macromycetes from the subtropical, evergreen, broad-leaved forests in China 183-194
THIND, K. S., see SHARMA & al.
THORN, R. G. The **"Pleurotus silvanus"** complex 27-66
THORN, R. G. & G. L. BARRON. **Nematoctonus** and the tribe Resupinateae in Ontario, Canada 321-453
TOMINAGA, KIYOSHI, see UDAGAWA & al.
UDAGAWA, SHUN-ICHI, see HORIE & al.
UDAGAWA, SHUN-ICHI, KIYOSHI TOMINAGA & TAKAFUMI HAMAOKA. **Scytalidium japonicum**, a new species, the causal agent of cattle bronchiolitis 279-286
VERMA, R. V., see KAMAL & al.
WALKER, CHRISTOPHER. Taxonomic concepts in the Endogonaceae: II. A fifth morphological wall type in endogonaceous spores 95-99
WALKER, CHRISTOPHER, see MILLER & WALKER
WALKER, CHRISTOPHER, C. M. PFEIFFER & H. E. BLOSS. **Acaulospora delicata** sp. nov. - an endomycorrhizal fungus from Arizona 621-628
WEITZMAN, I., M. R. McGINNIS, A. A. PADHYE & L. AJELLO. The genus **Arthroderma** and its later synonym **Nannizzia** 505-518
WHITE, JAMES F. & GARETH MORGAN-JONES. Studies in the genus **Phoma**. V. Concerning **Phoma pomorum** 461-466
WU, REN-JIAN, see TAN & WU

INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME TWENTY-FIVE

This index includes genera, infrageneric taxa, species, and infraspecific taxa. New taxa are underlined, as are the pages on which they are published.

ACANTHOCYSTIS 380, 382; geogenia 380, 408; leightonii 44, 48, 419; petaloides 408; silvana 39, 413; stratosa 383; sylvana 33
ACANTHONITSCHKEA 577
ACAULOSPORA 111, 114-116, 622, 627; appendicula 113; delicata 621, 622-624, 627; longula 623, 624, 627; myriocarpa 111, 112-116; nicolsonii 98, 623, 624; spinosa 98; sporocarpia 114; trappei 111, 114, 115, 624
ACREMONIUM album 157; arenarium 153, 157; bacillisporum 533
ACROGENOSPORA sphaerocephala 533
ACROSPORIUM cyparissiae 263
AERUGINOSPORA 639, 641, 642; hiemalis 643; singularis 642
AGARICOCHAETE 381, 383; indica 383; keniensis 383; mirabilis 381
AGARICUM infundibulum dimidiatum imitans 412, 415
AGARICUS 367; tribe Pleurotus 367; subtribe Camarophylli 639; applicatus 52, 367, 423; atrocaeruleus 396; atropunctus 642; bisporus 157; blakei 27, 30, 44, 54, 58; camarophyllus 639; campestris 613; cyphelliformis 29, 33, 62, 397; geogenius 408, 410; leightonii 48, 52, 56, 59; mastrucatus 400; mustaliensis 27, 30, 42, 44, 60, 62, 404, 405; niger 405; petalodes 381, 408, 410, 412; petaloides 367, 408, 409, 412; v spathulatus 408; pratensis 639; racodium 430; reniformis 390; rubellus 186; silvicola 186; spathulatus 408; striatulus 426, 427; sylvanus 27-29, 33, 34, 38, 42, 60, 62, 63, 397, 398; tremulus 410-412, 414-416, 418; trichotis 430; unguicularis 44, 48, 418
AGROCYBE praecox 186
AJELLOMYCES 508
ALLESCHERIELLA crocea 528, 533
ALTERNARIA 195, 198, 202-204, 206, 207, 210-212, 214, 287, 288, 291-293, 307, 464; alternata 200; angustiovoidea 195, 198, 200, 201; chrysanthemi 203, 210-212; conjuncta 294, 295; ethzedia 300, 301; euphorbiae 195, 197; euphorbiicola 195, 196, 199; eureka 305, 306; helianthi 203, 210-213; helianthicola 203, 214, 215; helianthinficiens 203, 204, 205, 209, 210; infectoria 297, 298, 299; leucanthemi 203, 211-213; photistica 303, 304; protenta 203, 207-210; tenuis 291; tenuissima 200; zinniae 203, 204, 209
ALYSIDIUM aureofulvum 533
AMANITA farinosa 186; vaginata 186
AMAURODERMA longipes 186; rugosum 186
AMETHICIUM 544; luteo-incrustatum 539, 542-544; rimosum 544
AMPHIGYMNIA 603
AMPHINEMA byssoides 67, 68
AMPHOROMORPHA 581, 583, 389-391, 596; entomophila 590
ANIPTODERA chesapeakensis 530, 532
ANTENNOPSIS 581, 583, 591, 596, 597 gallica 589, 591, 592, 597; gayi 589, 591, 592; grassei 589, 591, 592
ANTROMYCOPSIS broussonetiae 331
APHANOCLADIUM 157; album 158; arenarium 153, 157
APHYLLOTUS 324, 366
APHYSA plantaginis 256
AQUADISCULA appendiculata 529, 532
ARCTOPARMELIA 251-253; aleuritica 251, 252; centrifuga 251, 252; incurva 251, 252, 253; separata 251, 252-254; subcentrifuga 251, 252, 253
ARCYRIA denudata 532
ARRHENIA 416; acerosa 412, 414, 416
ARTHROPYRENIA apocalypta 571
ARTHROBOTRYS superba 533
ARTHRODERMA 505, 506, 508-512; benhamiae 509; borellii 505, 513; cajetani 505, 513, 514; ciferrii 509; cookiellum 505, 513; corniculatum 505, 513; curreyi 505, 506, 512; flavescens 509; fulvum 505, 513; gertleri 509; grubyi 505, 513, 514; gypseum 505, 514; incurvatum 505, 514; lenticularum 509; obtusum 505, 514; otae 505, 514; persicolor 505, 514; racemosum 505, 514; simii 507, 509; uncinatum 509; vanbreuseghemii 509
ARXIOMYCES 229, 230, 233; campanulatus 229, 231-233, 242; vitis 233
ASCOSPORA robertiani 256
ASPERGILLUS 327
ASTERELLA plantaginis 256
ASTERINA plantaginis 256; rubicola 256
ASTEROSTROMA 544; andinum 544; cervicolor 544; medium 544; ochroleucum 544
ASTEROTUS 321, 324, 366, 371, 377, 378, 380, 443; argentinus 49, 378; bicolor 378, 380; chilensis 378; dealbatus 376-380; graminus 378
ASTRAEUS hygrometricus 186
ATHELIA coprophila 67, 68
ATHELOPSIS lembosporum 544
AURICULARIA auricula 186; delicata 186; polytricha 186

BACTRIDIOPSIS 533
BACTRODESMIUM 529
BAEOSPORA 371
BEAUVERIA 153, 156-158; alba 156; amorpha 156; arenaria 154, 157; bassiana 153, 154, 156; brongniartii 153, 156; cylindrospora 155, 156; geodes 155, 156; nivea 154, 156; nubicola 156; parasitica 156; tundrensis 156, 671; velata 156
BEAUVERIOPHORA 157
BERKLEASMIUM concinnum 533
BERTIA 577, 578; moriformis 577-579
BEVERWYKELLA pulmonaria 528, 529, 534

BISPORA betulina 528, 534
BISPORELLA 136; citrina 529
BJERKANDERA adusta 186
BOLETUS edulis 186; roseus 483; speciosus 186
BOMBARDIA 629
BOMBARDIOIDEA 629
BOTRYOBASIDIUM candicans 81; lembosporum 544
BOTRYODIPLODIA 521
BOTRYOHYPOCHNUS hebelomatosporus 544
BOTRYOHYPOXYLON 629, 631; amazonense 629-633, 634, 636
BOTRYOSPHAERIA 520, 521, 630; dothidea 630, 631
BRETTANOMYCES 147, 148, 455, 457, 459; abstinens 147; anomalus 147, 457; bruxellensis 147; claussenii 147; custersianus 147, 455, 457; custersii 147; intermedius 147; lambicus 147, 455, 457, 459; naardenensis 147, 148
BULBOTHRIX 91; australiensis 85, 91; isidiza 85; lopezii 85, 86, 91; oliveirai 85, 86, 91; pustulata 86; viridescens 86
BYSSOMERULIUS hirtellus 544

CALATHINUS 367, 419; applicatus 419, 423; porrigens 419; striatulus 427; unguicularis 44
CALVATIA craniiformis 186; lilacina 186
CALYPTELLA 434
CAMAROPHYLLOPSIS 639-642; subg Camarophyllopsis 642; subg Hygrotrama 642; sect Hodophilus 642; sect Hygrotrama 642; atropuncta 642; dennisiana 642; foetens 642, 643; hiemalis 643; hymenocephala 643; phaeophylla 640, 643; phaeoxantha 643; rugulosa 643; schulzeri 640, 642; subfuscescens 643
CAMAROPHYLLUS 639; subg Aeruginospora 639; sect Cuphophyllus 639
CAMPANELLA 366, 382, 421
CANARIOMYCES 230
CANCELLIDIUM applanatum 529, 534
CANDELABROCHAETE 545; subg Botryodontia 545; africana 545, 546; cirrata 539, 545, 547; dispar 539, 546, 548; verruculosa 546
CANDELABRUM brocchiatum 529, 534
CANTHARELLUS cibarius 186; minor 186
CARLIA 520
CERATOCYSTIS 229
CERATOSPHAERIA pusilla 533
CERCOPHORA 'sp. I' 528, 530, 533
CERIPORIA reticulata 68, 69; tarda 69, 70
CERIPORIOPSIS mucidus 69, 70
CHAETOMIUM aureum 533; cochlioides 530, 533; funicola 528, 533; globosum 530, 533; seminudum 533; 'sp. I' 533; 'sp. II' 533
CHAETOSPHAERIA talbotii 534
CHALARA 134
CHLORIDIUM 529; botryoideum 534; chlamydosporum 534; clavaeforme 534; viride 528; virescens 534
CHRYSOSPORIUM 508, 511, 513
CLADOSPORIUM 529, 534; cladosporioides 534; oxysporum 534
CLATHROSPORA 287
CLAVULINOPSIS amoena 186
CLITOCYBE inversa 186; laccata 186; maxima 186
COCCOCHORA rubi 256
CODINAEA 534; gonytrichodes 529, 534; simplex 534
CODINAEOPSIS 529
COLEROA 255, 256; subg Coleroa 255; subg Hormotheca 255; chaetomium 255, 256; v americana 256; plantaginis 256; robertiani 256; rubicola 256
COLLETOTRICHELLA 521
COLLYBIA albuminosa 186; radicata 188; v furfuracea 188; velutipes 188
COLTRICIA cinnamomea 188
COMATRICHA tenerrima 532
CONCHOMYCES 382; bursaeformis 382; verrucisporus 382
CONFERTICIUM karstenii 553; ochraceum 553
CONIDIOBOLUS apiculatus 6
CONIOCHAETA kellermani 533; leucoplaca 533; velutina 533
CONIOPHORA 540, 542
CONIOPHOROPSIS 539, 540, 542; obscura 539, 540, 541
CONIOSCYPHA lignicola 534; varia 528, 534
COOKEINA sulcipes 168
COPRINUS atramentarius 188; micaceus 188
CORDYCEPIOIDEUS 581, 582, 587, 596, 597; bisporus 581, 586, 587, 597; octosporus 581, 586, 587, 597
CORDYCEPS 11, 158, 587; subg Eucordyceps 11, 12; sect Racemella 11, 12; subsect Confertae 12; corallomyces 12; ithacensis 11, 13; kirkii 12
COREOMYCETOPSIS 581, 582, 588, 596; oedipus 588-590, 597
CORIOLUS brachypus 469; consors 188; hirsutus 188; unicolor 188; versicolor 188
CORONOPHORA 578
CORTICIUM incrustans 322; luridum 188; portentosum 565; rickii 564
CRATERELLUS cornucopioides 188
CRIBRARIA tenella 532; violacea 532; vulgaris 157
CROCICREAS 136
CRONARTIUM fusiforme 284
CRYPTOSPHAERIA nitida 256; pullmanensis 166
CRYPTOSPORA 645; suffusa 647; v valsoides 647; valsoides v valsoides 648
CUCURBITARIA berberidis 629
CULICINOMYCES 157
CUPHOPHYLLUS 639-642; sect Aeruginospora 642
CYATHUS stercoreus 188
CYPHELLA 368, 435; conglobata 439; cupulaeformis 434, 435, 438; grisella 435
CYPHELLOPSIS 439; anomala 439; confusa 439
CYSTIDIODONTIA 546; artocreas 549-551; isabellina 539, 549
CYTOSPORA 23

DACTYLARIA chrysosperma 534; purpurella 528, 534
DALDINIA concentrica 630
DEBARYOSCYPHUS 119, 134; melanobasis 119, 120, 134-136
DEKKERA 147, 151, 455, 457, 459; anomala 151; bruxellensis 151, 459; claussenii 151; custersiana 455-459; intermedia 151, 459; lambica 455-457, 458, 459; naardenensis 147, 148, 150, 151
DENDRODONTIA bicolor 551
DENDROPHOMA 534
DENDROSPORIUM lobatum 534

DENDROTRICHOSCYPHA 126, 134; acanthopila 134; tetraspora 119, 120, 130, 132, 134
DENDRYPHIOPSIS atra 534
DERMATISCUM 163, 164; fallax 161-163; thunbergii 161-163
DIATRYPE 166; disciformis 21; discoidea 24; tristicha 523
DIATRYPELLA 166; aspera 20; decorata 19, 20, 22, 23; discoidea 19, 21-24; v alni 19-21; favacea 24; placenta 19, 20, 22; tocciaeanna 21; tocciaena 21
DICTYOPHORA indusiata 188
DICTYOPOLYSCHEMA 250
DIDERMA diademata 529, 532
DIDYMIUM trachysporum 528, 532
DIDYMOSPHAERIA manitobensis 256
DIMEROMYCES 581, 582, 585, 596, 597; isopterus 271, 585-587, 596, 597; majewskii 585-587, 597
DINEMASPORIUM 15, 16; adeanum 15-18
DIPLODIA 521
DISCOCHORA 519, 521; ilicis 521; philoprina 521
DISCOSPHAERINA 519-521
DOTHIDEA robertiani 256
DOTHIORELLA 521

EMMONSIELLA 508
EMPUSA 1
ENDOPHRAGMIELLA humicola 533
ENDOTHIA 147, 151, 455, 456, 459
ENGYODONTIUM 156; album 155, 156
ENTOMOPHTHORA 1, 2; anglica 1-3, 5, 6; aprophorae 6; carpentieri 2, 8; coleopterorum 2, 3, 8; elateridiphaga 5, 7; nebriae 8; pyralidarum 6; sphaerosperma 5; ssp elateridiphaga 5
ENTROPHOSPORA 111, 115, 116
EPICOCCUM purpurascens 461
ERYNIA 1-3, 5, 6, 8; subg Zoophthora 5, 8; anglica 1, 3, 4, 6-8; coleopterorum 1, 5; elateridiphaga 1, 3-8; nebriae 8; neopyralidarum 3, 6, 8; nouryi 3; petchii 6; radicans 3, 5; suturaliis 3, 5
ERYSIPHE 266; cinnamomi 266; convolvuli 268
EUTYPA 166
EUTYPELLA 166; parasitica 166
EVERSIA subopaca 534
EXIDIA glandulosa 188

FAERBERIA 367, 382, 383, 444
FIBRICIUM rude 551; subceraceum 539, 551
FIBRODONTIA 551; gossypina 551, 557; subceracea 551
FIBULOMYCES mutabilis 70, 71
FILOSPORELLA 'sp. CS-707-1' 529, 536
FLAVOPARMELIA 603, 604; amplexa 604; baltimorensis 604; callichroa 604; caperata 604; euplecta 604; exornata 604; ferax 604; gerlachei 604; haysomii 605; helmsii 605; jelineckii 605; pachydactyla 605; papillosa 605; rutidota 605; soredians 605; springtonensis 605; subamplexa 605
FOMES 469, 470; cajanderi 470, 472; carneus 469, 474; dochmius 470, 471, 477; feei 470, 479; ferreus 478; fraxineus 470; hemileucus 470; roseus 469-471, 483; rubritinctus 470; sagraeanus 469, 470, 479; subferreus 469, 470, 478; subroseus 470-472
FOMITOPSIS 470, 471; cajanderi 469, 471-474; carnea 469, 470, 472, 474; cupreo-rosea 469, 471, 476, 477; dochmia 469-472, 477-479; feei 469, 470, 472, 479-481; lilacino-gilva 469, 472, 481-483; rosea 469, 471, 472, 483-485; subrosea 472
FUSICOCCUM 630

GAILLARDIELLA 577
GANODERMA applanatum 188; japonicum 188; lucidum 188
GEOPETALUM 380, 382, 383, 444; subg Acanthocystis 368, 383; subg Phyllotus 368, 383; angustatum 383; carbonarium 380, 382, 383; cyphelliforme 33; geogenium 408; mastrucatum 400; petalodes 344, 408, 410; petaloides 380; rickenii 414, 416, 418; striatulum 427; v applicatum 423; sylvanum 33; unguiculare 44
GIGASPORA 95
GLIOCLADIUM deliquescens 534; microsporum 157
GLIOMASTIX murorum 534
GLOEOCORTICIUM 539, 551; cinerascens 539, 551, 552
GLOEOCYSTIDIELLUM lactescens 553, 555; porosellum 553; triste 539, 553, 554; turpe 555
GLOEOPHYLLUM trabeum 71, 81
GLOIOCEPHALA 371
GLOMUS 95, 111, 115, 116, 217, 225; albidum 98; diaphanum 111, 115; etunicatum 225; geosporum 226; maculosum 217, 218, 220, 223-226; microcarpum 111, 115; multisubstensum 226; occultum 111, 115; versiforme 226
GNOMONIA 533
GNOMONINA 520
GONYTRICHUM macrocladium 528, 534
GRANULOCYSTIS 273, 277; flabelliradiata 277
GUEPINIA spathularia 188
GUIGNARDIA 519-521; bidwellii 519-521
GYMNOASCUS gypseus 514

HAINESIA 534
HALOSARPHEIA retorquens 530, 533; 'sp. I' 533
HAMATOCANTHOSCYPHA 126, 135
HANSENIASPORA 148
HAPALOPILUS nidulans 72
HELICODENDRON conglomeratum 529, 534; triglitziensis 529, 534; tubulosum 529, 534; westerdykiae 529, 534
HELICOON 534; 'sp. I' 529
HELMINTHOSPORIUM helianthi 210
HENDERSONULA toruloidea 279, 280, 283, 284
HIRSUTELLA 158
HODOPHILUS 641, 642; foetens 641
HOHENBUEHELIA 28, 30-32, 38, 42, 44, 48, 50, 59, 60, 62, 63, 321-323, 325, 327, 336, 340, 342, 344, 346, 358, 360, 361, 366-368, 370, 371, 374, 380-383, 387, 420-422, 433, 441-444; strp Petaloides 344, 346, 348, 375; angustata 330, 334, 336, 375, 383, 384, 387, 388, 410; applicata 423; approximans 361, 362, 364, 376, 388, 390, 491; atrocaerulea 32, 56, 396, 397; v dendrocystis 397; v grisea 322, 361, 364, 375, 376, 390-392, 394, 402, 441; auriscalpium 344, 346, 410, 412, 443; burseaformis 382; crustosa 406; culmicola 342; cyphelliformis 27, 30, 32, 33, 34,

[HOHENBUEHELIA cyphelliformis] 36, 38, 40, 42, 63, 336, 342, 361, 362, 364, 376, 381, 383, 397, 398, 441; fluxilis 397; geogenia 322, 351, 408; grisea 391, 396; longipes 323, 332, 375, 383, 398-400, 442; mastrucata 352, 375, 400-402, 404; mustaliensis 27, 30, 32, 62, 364, 376, 404-406; nigra 32, 42, 44, 50, 60, 361, 362, 364, 376, 405, 406, 413, 441; panelloides 323; petalodes 346, 350, 351, 369, 375, 380, 408-410, 412, 415, 416, 441, 443; petaloides 344, 346, 410; pinacearum 27, 30, 32, 34, 38, 40, 42, 44, 46, 58, 63, 330, 337, 338, 376, 406, 412, 413, 420, 424; portegna 340, 397; recedens 412, 416; reniformis 32, 48, 60, 376, 390; rickenii 348, 410, 414-416; subbarbata 406; tremula 322, 346, 348, 350, 375, 410, 412, 414-416, 441; unguicularis 27, 28, 32, 34 44, 46, 48, 54-56, 63, 330, 337, 338, 376, 377, 406-408, 418, 419
HORMIACTIS 'sp. I' 534
HORMISCIOIDEUS 581, 583, 591, 596; filamentosus 586, 591, 597
HORMOTHECA 255, 256; geranii 255, 256; plantaginis 256; robertiani 255, 256; rubicola 256
HYALOSCYPHA 119, 120, 126, 128, 135; himalayensis 119, 120, 127, 128, 130; lachnobrachya 128; parvula 130; pusilla 128; stevensonii 130; uncinata 119, 120, 124, 128
HYDNUM artocreas 546, 549; indicum 549
HYDRABASIDIUM subviolaceum 555
HYGROCYBE 639, 640; subg Cuphophyllus 639; sect Hygrotrama 641; nitrata 641
HYGROPHORUS 639; sect Camarophyllopsis 641; sect Hygrotrama 641; subsect Microspori 641; foetens 643; hymenocephalus 643; microsporus 641; miniatus 188; paupertinus 641; peckianus 641; phaeoxanthus 643; rugulosus 643; v phaeophyllus 643; schulzeri 641; subfuscescens 643
HYGROTRAMA 639, 641, 642; dennisianum 639, 641, 642
HYMENOSCYPHUS 135
HYPHODERMA 159; argillaceum 555; deviatum 555; iguazuense 539, 555, 556; praetermissum 160, 555; puberum 160, 557; rude 557; setigerum 557
HYPHODERMELLA corrugata 557
HYPHODONTIA 557; sect Hyphodontia 562; alutaria 557, 560, 562; apacheriensis 539, 557; arguta 73, 74; aspera 557-558; brevidens 557; breviseta 557, 558; knysnana 558; lutescens 539, 558, 559; nudiseta 558; pallidula 560, 562; rimosissima 562; sambuci 557; tenui-cystidiata 539, 558, 559; wrightii 539, 560-562
HYPOCHNELLA violacea 562
HYPOCHNICIUM rickii 562
HYPOGYMNIA 604
HYPOTRACHYNA 87, 91; ensifolia 87; meridensis 85, 86, 87, 91; protenta 87
HYPOXYLON 633; bovei v microspora 188

ILEDON 629, 633; versicolor 629, 631, 633, 636
ILLOSPORIUM 505
INCRUSTOPORIA nivea 73, 74
INOCYBE asterospora 188; radiata 188; repanda 188; rimosa 188
IRPEX brevidens 557; cinnamomeus 188; hydneus 467, 468; lacteus 188
ISARIA 156; felina 155, 156

KABATIA 521
KAMESHWAROMYCES 247; globosus 247, 248-250
KLOECKERA 148
KNEIFFIA isabellina 546, 549, 551; setigera 551

LABOULBENIA 581, 582, 585, 587, 596, 597; brignolii 585, 586; felicis-caprae 585, 586; geminata 585, 586; ghanaensis 585, 586; hagenii 585, 586
LABOULBENIOPSIS 581, 582, 588, 596, 597; termitarius 588-590, 597
LACTARIUS camphoratus 608, 613; deliciosus 188; fuliginosus 188; hysginus 188; piperatus 188, 611, 613; volemus 188
LACTOCOLLYBIA 383
LAESTADIA 519, 520; alnea 519, 520
LASIOBERTIA 579
LASIODIPLODIA 521
LASIOSPHAERIELLA 577, 578
LASIOSPHAERIOPSIS 569, 575, 578; salisburyi 574-576; stereocaulicola 569, 570, 571, 573, 575-577, 579
LENTINUS 185; subnudus 188
LENZITES betulina 188
LEPIDOPTERELLA palustris 529, 533
LEPIOTA americana 188
LEPTOSPHAERIA 569, 575; apocalypta 569, 571, 577; noonae-daniae 578
LEPTOSPHAERULINA 287
LEVEILLULA 260, 267; simonianii 259-261; taurica f thevenotiae 259; thevenotiae 259
LEWIA 287, 289-293; ethzedia 299, 301; eureka 292, 304, 305; infectoria 293, 294, 296, 297, 299; photistica 292, 302, 303; scrophulariae 290, 292-294, 295, 299
LICHEN caperatus 604; centrifugus 251, 252; incurvus 252; multifidus 252
LIMACIUM 639
LINDERIELLA columnata 188
LITSCHAUERELLA 273
LOCULOHYPOXYLON grandineum 629, 630
LUTTRELLIA estuarina 530, 533
LYCOPERDON pyriforme 188
LYSURUS mokusin 188

MACROPHOMOPSIS 630
MACROSPORIUM euphorbiae 195, 196, 199
MARASMIELLUS 421
MARASMIUS sect Pleurotopsis 380; broomei 34; oreades 188; spodoleucus 33
MASSOSPORA 1
MATTIROLELLA 581, 583, 594-597; crustosa 594; silvestrii 594
MELANOCEPHALA triseptata 529, 534
MELANOSPORA 229-231, 233, 236, 239, 243
MERULIUS hirtellus 544
METATRICHIA vesparium 532
MICROASCUS 229
MICROPORUS cupreo-roseus 476
MICROSPHAERA 260; akebiae 262, 263; alni 260, 262, 263; alphitoides 266; clethrae 260; itoana 259, 260, 261; menispermi 262; miyabeana 263; orixae 259, 260, 261; paederiae 259, 261, 262; schizandrae 262, 263; sparsa 264; staphyleae 260; wallrothii 259, 262, 265
MICROSPHAEROPSIS 535

MICROSPORUM 508, 511-513; gypseum 506, 512; persicolor 512
MICROSTELLA pluvioriens 426
MICROSTOMA 23; vulgare 23
MICROTHECIUM 230
MICROTHELIA 574; manitobensis 256
MOLLIARDIOMYCES 165, 166, 168; crispatus 165, 167
MOLLISINA 134; uncinata 134
MOLLISINOPSIS 119, 120, 122, 124; aurantiaca 119-121, 122, 124; filicis 122, 124; indica 122, 124
MONACROSPORIUM 535
MORCHELLA esculenta 188
MUNKIELLA robertiani 256
MUTINUS bambusinus 188
MYCOSPHAERELLA plantaginis 256; theissenii 256
MYRIODONTIUM keratinophilum 155, 157

NAEMATOLOMA fasciculare 190
NAIS inornata 528, 530, 533
NANNIZZIA 505, 506, 508-512; borellii 508, 513; cajetani 507, 510, 513-515; cookiella 508, 513; corniculata 513; fulva 513; grubyi 506, 513-515; gypsea 514; v gypsea 514; incurvata 506, 514; obtusa 506, 514; otae 507, 508, 510, 514; persicolor 508, 514; quinckeani 514; racemosa 514
NEMATOCTONUS 28, 31, 48, 50, 62, 321-331, 334, 350, 352, 354, 360-362, 366, 368, 369, 371, 373, 374, 381, 382, 386, 392, 402, 420, 423, 434, 439, 441-443; angustatus 322, 330, 332, 333, 334, 336, 387; bicatenulatus 351; brevisporus 322, 330, 332, 337, 338, 413, 419; campylosporus 324, 325, 330, 332, 338, 340, 362, 397; concurrens 323-325, 330, 332, 342, 346, 362, 364, 441; cylindrosporus 322, 333, 344, 346, 348, 376, 443; geogenius 322, 332, 333, 346, 348, 350, 351, 366, 409, 412, 415, 441, 443; hamatus 322, 329, 332, 333, 351, 352, 354, 361, 402; haptocladus 323-325, 330, 332, 346, 354, 360, 366, 441; leiosporus 324, 325, 329, 333, 354, 356, 358, 375, 441; leptosporus 324, 327, 328, 333, 358, 441; lignicola 324, 328, 331; pachysporus 324, 325, 328, 330, 333, 354, 358, 360, 361; reniformis 351; robustus 324, 328, 332, 338, 340, 342, 354, 361, 362, 364, 390, 394, 398, 406, 441; subreniformis 322, 332, 358, 364, 366; tripolitanius 324, 328, 332; tylosporus 324, 327, 328, 333, 441
NEPHROMA 254
NETA lignicola 529, 535; patuxentica 528, 529, 535
NITSCHKIA 577; leonensis 579

OIDIUM 266, 268; acrocladum 267; alphitoides 266; araliacearum 259, 268; bauhiniae 267; caesalpiniacearum 259, 267; candicans 74, 75, 81; cinnamomi 259, 266; cinnamomi-japonici 259, 266; cyparissiae 263; erysiphoides 267; v stapeliae 267; f cinnamomi 266; f ipomoeae 268; f nephelii 267; euphorbiae-hirtae 263; ipomoeae 259, 268; nephelii 259, 267; pedilanthi 263; robustum 259, 268; schmiedeknechtii 259, 266; stapeliae 259, 267; urenae 266
OLIGONEMA flavidum 528, 532; schweinitzii 532
OMPHALARIA polyglossa 494
OPHIOCERAS 'sp. I' 533
OPHIOVALSA 645, 648, 649; betulae 645, 646, 649, 650; femoralis 645, 646, 649, 650; suffusa 645, 646, 648-650; valsoides 645, 647-650
OSMOPORUS 470; dochmius 477
OVULARIOPSIS acroclada 267

PACHYBASIUM niveum 156
PANELLUS 366, 374, 382, 421; dealbatus 378; patellarilis 421; patellaris 382; ringens 421; serotinus 382; stipticus 421; violaceofulvus 27, 30, 44, 59
PANUS angustatus 383, 410; bicolor 378-380; dealbatus 378; rudis 190; sprucei 378-380
PARAPHAEOSPHAERIA 287
PARMELIA 251; subg Amphigymnia 603; sect Cyclocheila 603; sect Subflavescentes 603; subsect Eciliatae 603; aleuritica 252; amplexa 604; antarctica 604; baltimorensis 604; birulae 252; v grumosa 252; caperata 603, 604; v exornata 604; v isidiophora 605; centrifuga 252; v dealbata 252; v muscivaga 252; diffugiens 252; euplecta 604; ferax 604; gerlachei 604; groenlandica 252; haysomii 605; helmsii 605; hottentotta 251; jelineckii 605; muscivaga 252; pachydactyla 605; papillosa 605; recurva 252; rutidota 605; separata 252; soredians 605; springtonensis 605; subcentrifuga 252; subtabacina 85
PARMOTREMA 88, 92, 93, 603; apricum 90; betaniae 85, 87, 92; catarinae 85, 87, 92; crinitum 88; dilatatum 90; dominicanum 90; fumarprotocetraricum 85, 88, 92; gardneri 89, 90, lobulatum 85, 88, 92; madilynae 85, 88, 89, 93; melanothrix 87; mellissii 89; pardii 88; pseudograyanum 88; recipiendum 88; schindleri 85, 89, 93; setchellii 89; sorediiferum 85, 89, 93; subsumptum 88; subtinctorium 88; umbrosum 89; virescens 85, 90, 93
PASSERINIELLA discors 533
PAXILLUS involutus 190
PELTIGERA rufescens 574, 575
PEMPHIDIUM rubicola 256
PENICILLIUM 327, 535
PENIOPHORA rimosa 565
PERICHAENA chrysosperma 532; corticalis 532; depressa 532
PERSICIOSPORA 229, 236, 240; japonica 229, 231, 233; 234, 236, 242, 244; masonii 236; moreaui 236
PEZIZA 435; anomala v poriaeformis 435; poriaeformis 435; sepiatra 190; sylvestris 190; vesiculosa 190
PHAEOISARIA clematidis 528, 535
PHAEOSTOMA 233
PHALLUS rubicundus 190
PHANEROCHAETE 273; arizonica 76, 81; carnosa 76, 77; flabelliradiata 273, 277
PHELLINUS pomaceus 190
PHIALOCEPHALA bactrospora 535; humicola 535; illini 529, 535
PHIALOCLADUS 157
PHIALOPHORA 236; radicicola 535; richardsiae 535; verrucosa 535
PHILLIPSIA 165; crispata 165-168, 170
PHLEBIA 544; lacteola 77, 78; lilascens 77, 78

PHOLIOTA adiposa 190
PHOMA 461, 464, 535; americana 461, 464; epicoccina 461; glomerata 464; pomorum 461, 464; prunicola 461; sorghina 464
PHYLLACHORELLA 520; micheliae 520
PHYLLOSTICTA 519, 521
PHYLLOTA 419
PHYLLOTUS 367, 419; applicatus 419, 423; mustaliensis 404; striatulus 427; unguicularis 44
PHYTOPHTHORA 101, 102, 107-110; avicennae 101, 109; bahamensis 101, 108; batemanensis 101, 109; epistomium 101, 108; japonica 109, 110; mycoparasitica 101, 108; operculata 101, 108; polymorphica 101, 109; spinosa v lobata 101, 108; v spinosa 101, 108; vesicula 101, 108
PLACOSPHAERIA 521
PLAGIOSTOMA 519, 520
PLEOSPORA 287-293, 569; subsect Pleospora 292; subsect Vulgaris 292; alternariae 290, 291; gigaspora 289; herbarum 287-290, 292; infectoria 214, 288, 290-292; sarcinula 291; scrophulariae 288, 290, 292, 294
PLEURODESMOSPORA 157
PLEUROTHECIUM recurvatum 535
PLEUROTOPSIS 380, 383; spodoleucus 33, 380-381, 383
PLEUROTUS 27, 29, 30, 40, 42, 322, 323, 367, 368, 372, 374, 375, 387, 396, 443, 444; sect Acanthocystis 380; alboater 31, 52; alboniger 31, 49, 50, 52, 56, 421, 422; angustatus 383; applicatus 29, 40, 56, 58, 423; f rhacodium 430; approximans 388; atrocaeruleus 396; v griseus 367, 390; v minimus 44, 46, 48, 54, 56, 418; atropellitus 27, 30, 42, 44, 46, 54, 56, 58, 63, 413, 424, 428; campanulatus 34; cyphelliformis 33; cystidiosus 331; geogenius 408, 416; griseus 391, 394, 397; longipes 398; mastrucatus 400, 402; mustaliensis 404; niger 30, 405; ostreatus 190, 367, 438; petaloides 388, 402, 408; v eupetaloides 383; f americana 383, 387; pinsitus 322; reniformis 390; rhacodium 430; rickenii 414; silvanus 27-31, 39, 42, 44, 49, 63, 368, 413, 422; spathulatus 408, 410; stratosus 383, 387; striatulus 367, 427; sylvanus 29, 33; unguicularis 30, 31, 39, 40, 44, 46, 48, 63, 368, 413, 418; valesiacus 402; vetlinianus 421
PODOSCYPHA diaphana 190
POLYPORUS 375, 470; carneus 469; cupreoroseus 476; dochmius 477; feei 469, 470, 479; ferreus 477; lilacino-gilvus 481; roseus 483; rubidus 469, 479; sagraeanus 470
POLYSTICTUS cupreo-roseus 476; cupreovinosus 476; feei 479; lilacino-gilvus 481
PORIA apacheriensis 557
PORIODONTIA 557
POROTHELEUM 368, 435; subg Stigmatolemma 433; poriaeforme 435
PSATHYRELLA candolleana 190; velutina 190
PSEUDAEGERITA corticalis 529, 535
PSEUDOCOPRINUS crenatus 190
PSEUDOHALONECTRIA lignicola 530, 533; 'sp. I' 533
PSEUDOPARMELIA 603, 604; amplexa 604; baltimorensis 604; callichroa 604; caperata 603, 604; chapadensis 603; cyphellata 603; exornata 604; ferax 604; gerlachei 604; hypomilta 603; pachydactyla 605; papillosa 605; rutidota 605; soredians 605; sphaerospora 603; subamplexa 605
PYCNOPORUS cinnabarinus 78, 79
PYRENOCHAETA 535
PYRENOPHORA 287; alternarina 290, 291
PYRIMADOSPORA 'sp. CS-575-4' 529, 536
PYTHIOMORPHA oryzae 109
PYTHIUM 101, 102; adhaerens 105; angustatum 105; apleroticum 105; aquatile 101, 105; chondricola 101, 102-105; coloratum 105; diclinum 105; dissotocum 105; grandisporangium 101, 105-107; marinum 101, 105; monospermum 105; papillatum 105; perniciosum 105; porphyrae 101, 105; salinum 101; sulcatum 105; tenue 105

RADULOMYCES 553; confluens 72, 73, 564
REBENTISCHIA unicaudata 533
RESUPINATUS 27, 28, 31, 32, 42, 50, 321, 322, 324, 325, 366-368, 370, 371, 373-375, 377, 378, 382, 383, 408, 419-421, 423, 433, 439, 442-444; subg Asterotus 377; alboniger 27, 31, 32, 40, 42, 49, 50, 52, 54, 56, 63, 374, 377, 378, 408, 413, 421, 422, 443; applicatus 27, 30, 31, 33, 44, 48, 50, 56, 78, 80, 368, 374; 376, 380, 406, 419, 421, 423, 424, 426, 428, 430, 433; approximans 388; argentinus 49; bicolor 378; campanulatus 34; cyphelliformis 33, 368, 382, 420; griseus 391; kavinii 421, 434; leightonii 60; niger 405; rhacodium 430; silvanus 28, 29, 31, 39, 40, 63, 323, 420; striatulus 33, 50, 52, 58, 372, 374, 376, 378, 424, 426-428, 430, 433, 438, 439; subrhacodium 430, 433; sylvanus 29, 33, 420; trichotis 33, 376, 406, 430, 432, 433; unguicularis 44, 420
RHAGADOSTOMA 578
RHINOCLADIELLA anceps 535
RHODOCYPHELLA 434
RHODOPHYLLUS sinuatus 190
RIMBACHIA 416
ROLLANDINA 512; capitata 512
RUSSULA 609, 618; subsect Lactarioideae 607, 608, 613, 617, 619; subsect Plorantes 607; adusta 190; angustispora 607-609, 613, 615, 617-619; brevipes 607, 613, 619; cascadensis 613; foetens 190; inopina 619; integra 190; lepida 190; nigricans 190; pulchella 190; romagnesiana 619; subdepallens 190; vesca 190; vesicatoria 607-610, 613, 618; virescens 190

SCHIZOPHYLLUM commune 190
SCLEROTIUM rolfsii 535
SCOLECOBASIDIUM constrictum 535
SCOPINELLA 230
SCOPULOIDES rimosa 565
SCYTALIDIUM 279, 280, 284, 285; allahabadum 284, 285; fulvum 285; hyalinum 280, 283, 284; indonesiacum 284, 285; japonicum 279, 281, 282, 284, 285; lignicola 280, 283, 285; terminale 284; thermophilum 284, 285; uredinicola 284
SCYTINOSTROMA albo-cinctum 565; ochroleucum 565; portentosum 565
SCYTINOTOPSIS 419; applicatus 419
SELENOPHOMA 521
SELENOSPORELLA 535
SEMIDELITSCHIA agasmatica 629, 630

SISTOTREMA brinkmannii 565
SOLENIA 368, 435; poriaeformis 435
SORDARIA 'sp. I' 533; 'sp. II' 533
SPADICOIDES atra 535; bina 535; 'sp. CS-754-1' 536
SPARASSIS crispa 190
SPHAERIA 570, 574; bidwellii 519; geranii 256; herbarum 288; ilicis 521; microstoma 23; philoprina 521, 522; scrophulariae 287, 290, 294; stereocaulicola 569, 570, 573, 575
SPHAERODES 229, 230, 239, 240; episphaeria 239; fimicola 240; micropertusa 229, 231, 236, 238, 240, 242
SPHAERONAEMELLA 230
SPHAEROTHECA euphorbiae 263; euphorbiae-hirtae 259, 263-265; fuliginea 263
SPINULOSPHAERIA 578
SPONGIPELLIS leoninus 190
SPORIDESMIELLA 166, 168; brachysporioides 166; hyalosperma v hyalosperma 166; v novaezelandiae 166
SPORIDESMIUM hyalospermum 528, 535; taxodii 529, 535
SPOROSCHISMA mirabile 535; saccardoi 528, 535
STACHYBOTRYS chartarum 231, 232; cylindrospora 535
STAPHYLOTRICHUM coccosporum 535
STECCHERINUM 467, 468; helvolum 190; ochraceum 467, 468; subochraceum 467, 468
STEMONITIS smithii 532
STEMPHYLIUM 287-289, 291, 292; botryosum 288, 289; majusculum 289
STEREOCAULON 574; alpinum 570-574; glareosum 572; humbertii 572, 573; paschale 572; rivulorum 572, 573
STEREUM duriusculum 565; hirsutum 79, 81; purpureum 190; rameale 190; spectabile 190
STIGMATEA robertiani 256; rubicola 256
STIGMATOLEMMA 321, 324, 366, 371, 374, 375, 421, 433-435, 443; conspersum 377, 435, 438; incanum 433; poriaeforme 374, 377, 434-436, 438; taxi 434, 435, 438
STILBELLA erythrocephala 535
STROBILOMYCES floccopus 190
STROMATOCYPHELLA 321, 324, 366, 371, 421, 434, 439, 443; aceris 439; conglobata 377, 421, 434, 439-441; lataensis 439
STROMATOSCYPHA huia 434
SUBULICYSTIDIUM longisporum 565
SUILLUS flavus 190; luteus 190
SYSPASTOSPORA 229, 230, 243; boninensis 229, 231, 240-243; parasitica 243

TAENIOLELLA americana 529, 535
TALAROMYCES flavus 528, 533; v flavus 533
TAPHRINA 487-491; athyrii 490; faulliana 490; fusca 490; hiratsukae 490; polystichi 487, 491; vestergrenii 490, 491; wettsteiniana 491
TERMITARIA 581, 583, 584, 592, 593, 595-597; coronata 581, 592-594, 597; longiphialidis 593, 594; longispora 597; macrospora 593, 594, 597; rhombicarpa 593, 594, 597; synderi 581, 592-594, 597; thaxteri 593, 594
TERMITARIOPSIS 596
THAXTERIA 577, 578
THELEPHORA confluens 564
THOZETELLA tocklaiensis 528, 535
THYREA 493, 497, 501, 502; divergens 493, 495, 497, 499, 501-503; giradii 502, 503; plectospora 493, 497, 502; polyglossa 493-495, 497, 499, 501-503; pulvinata 495, 497; rotundata 495, 502, 503
TOLYPOCLADIUM 153, 157; cylindrosporum 156; geodes 156; inflatum 153, 156; niveum 153, 156; nubicola 156; parasiticum 156; tundrense 156
TOMENTELLA pilosa 80, 82
TORRUBIELLA 158
TORULA herbarum 535
TRAMETES 470; carnea 469, 472, 475; cinnabarina 190; v sanguinea 190; corrugata 190; cupreo-rosea 470, 476; dickinsii 190; feei 469-471, 479; gallica 190; griseo-lilacina 481; lactinea 190; lilacino-gilva 470, 471, 481; rosea 481, 483; roseo-zonata 472; sagraeanna 470; subrosea 469, 470, 472; violacea 481
TRECHISPORA farinacea 566; regularis 566; vaga 80, 82
TREMATOSPHAERIA fallax 530, 533
TREMELLA fuciformis 190
TRICHOCLADIUM lobatum 535; moenitum 529, 535
TRICHODERMA harzianum 528, 529, 535
TRICHOLOMA sordidum 192
TRICHOPHYTON 508, 511-513; persicolor 508
TUBULICIUM 273; vermiferum 566
TUBULICRINIS 273, 277; gracillimus 277; hamatus 277

UNCINIELLA 126, 135
UNCINULA 266; kusanoi 264; matsunamiana 259, 264, 265; verniciferae 264; viburni 259, 264, 265
UNGUICULELLA eurotioides 119, 120, 136, 138
URCEOLUS 381, 383; sambucinus 34, 381, 383
USTULINA deusta 430

VALSA 23
VALSEUTYPELLA 523; multicollis 523, 524, 526; tristicha 526
VANBEVERWIJKIA spirospora 529, 535
VARARIA pallescens 536; rugosispora 566; sphaericospora 566
VARICOSPORIUM 'sp. I' 529, 535
VERMICULARIOPSIELLA 18; immersa 17, 18
VERTICILLIUM microsporum 157; 'sp. I' 535
VIRGARIA nigra 535

WIESNERIOMYCES laurinus 535

XANTHOCHROUS nilgheriensis 192
XANTHOMACULINA 251
XANTHOPARMELIA 251, 252; alectoronica 252; centrifuga 251, 252; incurva 252; separata 252; subcentrifuga 254
XENASMA praeteritum 566; pruinosum 566; rimicola 566
XENOSPHAERIA apocalypta 569, 571, 572, 575
XEROCOMUS chrysenteron 192
XYLOHYPHA 536

ZALERION varium 530, 536
ZOOPHTHORA 5; elateridiphaga 5, 6
ZOPFIELLA latipes 528, 530, 533; lundqvistii 529, 533

ERRATA, VOLUME FIVE

Page 70	line 33	for Europaei 634,	read Europaei 654,
94	21	for D-7968	read D-7698
106	4-5	for ISOTYPUS: CUP-Fairman 619 (18-56)	
		read PARATYPUS: CUP-Fairman 827 (18-56), (same data except: 2.IX.1920).	
152	28	for D-1321	read D-6321
170	28	for CUP-D76?9	read CUP-D-7609
181	18	for CUP-D-6288	read CUP-D-6228
207	39	for 2?53	read 2053
233	12	for CUP-D-7707	read CUP-D-7709
238	20	for 32525	read 34626
245	38	for CUP-D-5821	read CUP-D-5281
	39	for D-142	read D-7677
	40	for D-7648	read D-7678
	42	for D-1749	read D-7749
251	1	for Pragmopara	read Pragmopora
327	19	for 32627; 32640	read 34627; 34640

ERRATA, VOLUME TWENTY-THREE

Page 2	line 20	for difficult	read different
137-139		Add 5 to each page number of Author Index	
253	line 25	for Abdulla	read Abdullah
SPINE	for i-iv.	July-September 1985	
	read i-iv, INDICES.	July-September 1985	

ERRATA, VOLUME TWENTY-FOUR

Page 513	line 31	for CUP 61695	read CUP 60695
521	45	for (G-GK 12509);	read (G-GK 12590);
540	32	FOR for clo	hlorata
		READ for clorata read chlorata	
SPINE	for 23: 1-516 + i-iv.	July-September 1985	
	read 24: 1-540 + i-iv, INDICES.	October-December 1985	

ERRATA, VOLUME TWENTY-FIVE

Page 2	line 25	for E. anglica	read Entomophthora anglica
5	14	for E. sphaerosperma	
		read Entomophthora sphaerosperma	
8	1	for E. anglica	read Erynia anglica
	49	for E. carpentieri	
		read Entomophthora carpentieri	
39	21	for silvanus read silvana	
85	30	for P. (Bulbothrix)	
		read Parmelia (Bulbothrix)	
126	34	for DENOROTRICHOSCYPHA	
		read DENDROTRICHOSCYPHA	
156	43	for Beauveria tundrense	
		read Beauveria tundrensis	
188	4	for cinamomea	read cinnamomea
190	1	for Harst.	read Karst.
	12	for candolieana	read candolleana

ERRATA, VOLUME TWENTY-FIVE (continued)

Page 190	line	27	for Spingipellis	read Spongipellis
203	line	7	for 1985),	read 1986),
216		37	for [1985].	read 1986.
252		51	FOR P. groenlandica	READ P. groenlandica
267		7	FOR Leveillula	READ Leveillula
330		25	for addtion	read addition
380		40	for geogenius	read geogenia
406		28	for niger	read nigra
412		3	for A.	read Agaricus
		7	for A.	read Agaricus
413		46	for silvanus	read silvana
415		39	for A.	read Agaricus
416		4	for A.	read Agaricus
		6	for A.	read Agaricus
434		3	for cupliformis	read cuplaeformis
481		22	for violaceus	read violacea
528		42	for funicolum	rtead funicola
529		15	for Trichochladium	read Trichocladium
532		25	for Acyria	read Arcyria
		26	for Comatrichia	read Comatricha
		28	for Cribaria	read Cribraria
		29	for Cribaria	read Cribraria
		33	for vesparum	read vesparium
533		10	for funicolum	read funicola
		37	for Rabentischia	read Rebentischia
566		29	for rimicolum	read rimicola
577		8	for L.	read Lasiosphaeriopsis
604		1	for P.	read Pseudoparmelia

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PUBLICATION DATES FOR MYCOTAXON

Vol. **24**, Oct.-Dec. 1986	11 December 1986
Vol. **25**(1), Jan.-Mar. 1986	19 February 1986

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